The waste lines between WM-102 and Valve Box A3A were encased in split tile pipe (see Figure 5-41). When the drain line from Box A3A plugged, waste leaking from the valves into the valve box exited the box via the tile encasements leading to CPP-604. There was a long vertical section and short horizontal section of split tile encasement and an unlined concrete junction box between Box A3A and CPP-604. Waste could have leaked through the encasement joints, cracks in the encasement, or cracks and joints in the concrete junction box. The encasements could have been damaged by the mid-1950s project that installed Valve Box A3A on top of the original split tile encasement. That project also excavated an area 8 ft east of Valve Box A3A to approximately 30 ft below grade level to modify Lines PUA-1013 and PUA-203 and to install Valve Box A2. The excavation, construction, and subsequent soil settling associated with the mid-1950s project may have cracked the tile encasements associated with Box A3A, allowing leakage from the encasement into the soil. The concrete junction box and horizontal portion of the encasement were about 29 ft below grade, which is about the location of the high contamination or deep portion of CPP-79.

5.16.1.2 Waste Source Term. DOE-ID (2004) indicates the source term for the shallow leak was low-activity waste that was sent to the PEW evaporator for concentration (WINCO 1987). Two transfers of waste were made in which low-activity solution leaked to the soil. A transfer from the WCF on July 7, 1986 leaked 1,850 gal, and one from the NWCF on August 2, 1986, leaked 680 gal. Although both wastes were low-activity, PEW evaporator feed solution, the two wastes were significantly different in radiological activity.

The primary source of the WCF waste was process condensate from the concentration of SBW from the tank farm (WM-180) in the WCF evaporator (WC-114). The NWCF waste came from the decontamination facility (VES-NCD-123) and was generated by the decontamination of INTEC equipment. The WCF waste contained much higher activity than the NWCF waste. The WCF waste (sample log 860707-35) had a gross beta activity of 1.23E+06 beta/min/mL. The NWCF waste (sample log 860801-18) had a gross beta activity of 9.60E+03 beta/min/mL, two orders of magnitude below that of the WCF waste. Therefore, in additive terms, the NWCF waste contributed virtually no activity compared to that of the WCF waste. The WCF waste was process condensate from the WCF evaporator, which was concentrating waste from WM-180. The waste in WM-180 was old and most of it was generated in the early 1960s. As a result, most of the beta activity in the waste was due to Cs-137 and Sr-90. Assuming the gross beta was the result of Cs-137, Sr-90, and Y-90, the Cs-137 (and Sr-90) activity was about 1/3 of the total beta activity, or about 6.8E+03 d/s/mL (7.0E-04 Ci/gal).

The WCF waste was likely relatively high in H-3 and I-129 activity compared to other radionuclides because it was WCF evaporator condensate produced from concentrating tank farm SBW. The NWCF waste likely contained very low levels of I-129 and H-3 because it came from equipment decontamination (typically solid residue), which did not have a large H-3 or I-129 activity. Neither the WCF nor NWCF samples included I-129 or H-3 analyses. However, H-3 and I-129 analyses of the WM-180 waste that was concentrated in WCF are available. The WM-180 waste (log 830603-24) contained 965 d/s/mL (9.9E-02 mCi/gal) H-3, and 0.76 d/s/mL (7.8E-05 mCi/gal) I-129. If one assumes neither iodine nor tritium concentrated in the evaporation process, then the WCF evaporator condensate had the same H-3 and I-129 activity as the WM-180 waste. However, based on historical SBW sample data, the WM-180 I-129 analysis may be conservatively high (up to a factor of 10). Most SBW has less-than-detectable I-129 activities, so the WM-180 I-129 activity may have been a false positive value. However, it is a reasonably conservative starting point for use in a groundwater modeling effort. These I-129 and H-3 activity estimates are reasonable values for a source term for the 1,850 gal of WCF waste that leaked into CPP-79. In additive terms, the activity in the NWCF decontamination facility waste was negligible compared to the WCF waste.

There are no Tc-99 data for either of the CPP-79 wastes. An estimate of the Tc-99 activity in the WCF waste, based upon fission yield and comparison to Cs-137, is about 1.4 d/sec/mL (1.4E-04 mCi/gal).

The nitrate content of the WCF evaporator condensate would have been nearly the same as its acid content, since the primary ionic constituent of the waste was nitric acid. This means the nitrate in the waste that leaked was about 0.13 M (the concentration of the acid in sample log 860707-35). Although the NWCF waste had negligible activity compared to the WCF waste, it had a comparable nitrate content. The NWCF waste came from the decontamination of equipment, which often used nitric acid. The acid content of the NWCF waste that leaked was <0.14 M acid (sample log 860801-18). However, a sample of waste from the same source about a week later had an acid concentration of 0.15 M (sample log 860807-4). The waste that leaked likely had an acid content similar to that sampled a week later, which was similar to that of the WCF waste that leaked, or about 0.13 M.

5.16.1.3 Waste Volume Leaked to Soil. A leak occurrence report (WINCO 1987) provides the volume of waste that leaked into the shallow portion of CPP-79 as 1,850 gal from WCF and 680 gal from NWCF. The WCF volume may not include steam jet dilution, which would be an additional 130 gal (assuming 2,650 gal transferred with 5% jet dilution). There was no jet dilution with the NWCF waste because that transfer used a pump. Those volumes are well documented and are accurate to about 50 gal based on the type of instrumentation in use at WCF and NWCF.

5.16.1.4 Source Term Summary. The CPP-79 (shallow) site is a shallow, low-activity area believed to be the result of two leaks of PEW evaporator feed solution in 1986. Table 5-41 summarizes the activity of major radionuclides and mass of nitrate released at Site CPP-79 (shallow), assuming 1,850 gal of WCF and 680 gal of NWCF leaked to the shallow site.

Table 5-41. Estimate of major radionuclides and nitrate released at Site CPP-79 (shallow) from two releases.

Cs-137	Sr-90	H-3	Tc-99	I-129	NO_3
1.3 Ci	1.3 Ci	0.18 Ci	2.6E-04 Ci	1.4E-04 Ci	77 kg

5.16.2 Cleanup

Much of the contaminated soil at the CPP-79 (shallow) site is believed to have been removed from the release location and stockpiled during the 1993-1994 tank farm upgrade project. The amount of activity was not documented during the excavation activities. Soil was excavated down to approximately 30 ft below the tank farm surface. Reportedly, the majority of the soils excavated and stockpiled during the 1993-1994 tank farm upgrade were placed back into the excavation, but it is not documented where the soils from the CPP-79 (shallow) release were used as backfill.

5.16.3 Previous Investigations

Borehole CPP-79-1 was drilled near the release site (see Figure 5-40) during the OU 3-07 Track 2 investigation in 1992 (WINCO 1993). The borehole location was on a berm approximately 8 ft above the ground surface in the tank farm. As a result, the original land surface (or tank farm land surface) elevation corresponds to a depth of 8 ft bgs in the borehole. In the subsequent discussions, the depths have been adjusted to correspond to the tank farm land surface and not that of the berm.

Fifteen split-spoon samples were collected from CPP-79-1 and screened for gross beta-gamma radiation. Seven samples were selected from the zones having the highest radiation readings for further analysis. Two of the seven samples were duplicates collected between 24 and 28 ft below the tank farm land surface. One sample collected from the 33.5- to 34-ft interval below the tank farm land surface had significantly higher radiation levels. Based on field monitoring and soil analytical results from Borehole CPP-79-1, two distinct radionuclide contaminant zones are evident that originated from different sources. The uppermost zone was encountered between 14 to 22 ft below the tank farm land surface (CPP-79 [shallow]). This zone was characterized by gross alpha emissions slightly in excess of background levels and by gross beta emissions up to eight times the background level. The radionuclides found in this zone are attributed to the release of low-activity PEW evaporator waste that resulted in the CPP-79 (shallow) release site.

The top of the second radionuclide-contaminated zone was encountered in CPP-79-1 at a depth of approximately 31 ft below the tank farm land surface. This zone is characterized by radionuclide concentrations that are two to three orders of magnitude greater than those detected in the shallow zone and are the result of release of first-cycle, second-cycle, and process equipment wastes as described below in Section 5.17. All samples associated with the CPP-79 (shallow) release were analyzed for gross alpha-emitting and gross beta-emitting radionuclides. Samples collected above 28 ft below the tank farm land surface had relatively low activities of radionuclides, consistent with a release of WCF and NWCF decontamination solutions. Gross alpha activity was below background levels in samples collected between 16 ft and 28 ft below the tank farm land surface. Gross beta and Cs-137 activities remained above background levels from 14 to 22 ft below the tank farm land surface. The soil samples collected from 24 to 28 ft below tank farm land surface contained radionuclides near or below background levels.

The highest gross alpha, beta, and Cs-137 activities observed for the shallow release site were from the sample collected from 14 to 16 ft below tank farm land surface. The Cs-137 concentration in this sample was 20.9 ±1.5 pCi/g; the Sr-90 activity was 54.4 ±3.46 pCi/g. This sample also had detectable levels of U-238 and -235 that were near background levels and Pu-238 and -239 levels that were slightly above background concentrations. INL Site background levels for U-238, Pu-238, and Pu-239/240 have been determined to be 1.40, 0.0049, and 0.10 pCi/g respectively (INEL 1996).

Information on the lateral extent of the contamination around Borehole CPP-79-1 is provided by the results of samples from Boreholes A-61 and -62 (INEL 1995). These boreholes were drilled to the west and east, respectively, of Borehole CPP-79-1 (Figure 5-42).

Soil samples were collected and analyzed from depths of 28.5 to 30.5 ft and 38.5 to 40.3 ft in Borehole A-61. The highest gross alpha (1,230 ±20 pCi/g), gross beta (20,500 ±50 pCi/g), Sr-90 (3,360 ±30 pCi/g), and Cs-137 (25,000 ±2,000 pCi/g) concentrations were in the 28.5- to 30.5-ft sample from Borehole A-61. Other radionuclides detected in this sample include Am-241 (46 ±4 pCi/g), Pu-239/240 (319 ±10 pCi/g), and U-234 (2.1 ±0.1 pCi/g). Concentrations of these same constituents in the 38.5- to 40.3-ft sample were one to four orders of magnitude lower than in the shallower sample.

Samples were obtained from 2 to 4 ft and 40.3 to 41.8 ft in Borehole A-62. Concentrations of Sr-90 and Cs-137 in the near-surface soil sample from Borehole A-62 were 305 ±3 pCi/g and 730 ±5 pCi/g, respectively. Concentrations of these radionuclides were below background in the deeper sample from Borehole A-62. A comparison of ratios of the detected radionuclides in the sample from Borehole A-61 with the results from samples from Borehole 79-1 (Table 5-42) indicate that some similarities exist between the contamination, but not enough to determine if the contamination observed in A-61 originated from the same source as CPP-79 (deep). Borehole A-61 is farther from the known release location for the shallow contamination present in CPP-79-1 observed at 22 to 24 ft bgs, yet this borehole had higher concentrations for most contaminants, indicating that the release of low-activity PEW evaporator waste at CPP-79 (shallow) is not the source of contamination in A-61.

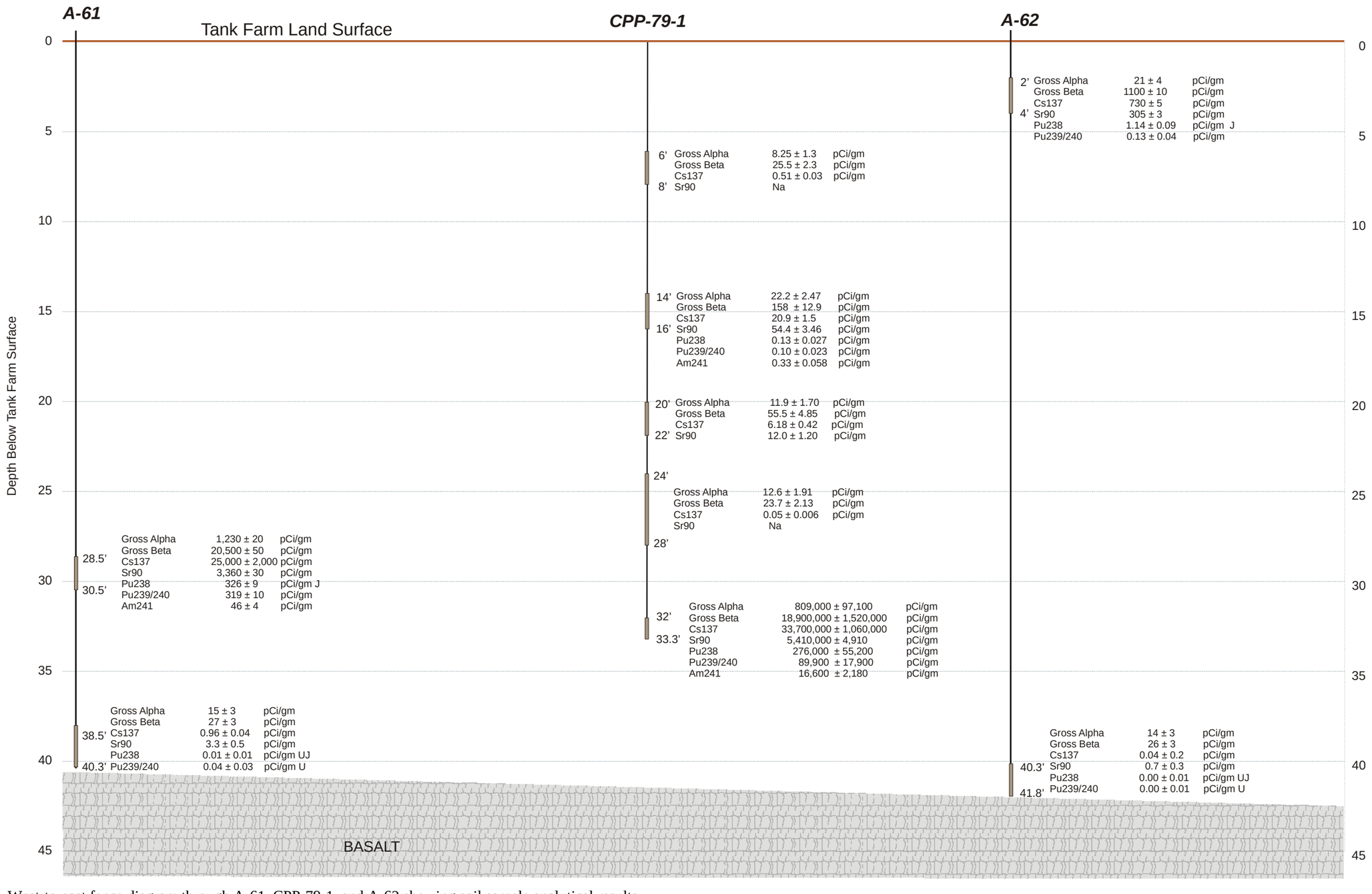

Figure 5-42. West-to-east fence diagram through A-61, CPP-79-1, and A-62 showing soil sample analytical results.

Table 5-42. Borehole sample result comparison table (results in pCi/g).

Radionuclides and Associated Ratios	Borehole CPP-79-1-Shallow (14–16 ft below tank farm surface)	Borehole CPP-79-1-Deep (32–32.5 ft below tank farm surface)	Borehole A-61 (28.5–30.5 ft bgs)	Borehole A-62 (2.0 – 4.0 ft bgs)
Radionuclides				
Gross alpha	22.2	809,000	1,230	21
Gross beta	158	18,900,000	20,500	1,100
Cesium-137	20.9	33,700,000	25,000	730
Sr-90	54.4	5,410,000	3,360	305
U-234	5.55	ND[a]	2.10	1.42
U-238	1.39	ND	1.50	1.67
Pu-238	0.13	276,000	326	1.14
Pu-239/240	0.10	89,900	319	0.13
Am-241	0.33	16,600	46	R[b]
Ratios of detected radionuclides				
Gross beta/ gross alpha	7.1	23.4	16.7	52.4
Gross beta/Sr-90	2.9	3.5	6.1	3.6
Cs-137/Sr-90	0.4	6.2	7.4	2.4
Pu-238/ (Pu-239/240)	1.3	3.1	1.0	8.8
Sr-90/(Pu-238 + Pu-239/240)	236	11.8	5.2	240

a. ND = Not detected. Uranium activity could not be quantified in the presence of the large amounts plutonium isotopes in the sample.
b. R = Result was rejected because of an out-of-control quality control parameter.

5.16.4 OU 3-14 Investigation

CPP-79 (shallow) was not identified as having data gaps requiring further investigation in the OU 3-14 RI/FS Work Plan; however, the OU 3-14 field investigation for CPP-79 (deep) also acquired information relevant to CPP-79 (shallow). That information is detailed in Section 5.17 and summarized in this section.

The western and eastern extents of CPP-79 (shallow) contamination are bounded by Probeholes CPP-79-10 (CPP-1883) and CPP-79-5 (CPP-1884), respectively. No contamination above 1 mR/h was observed in CPP-79-10 (CPP-1883), and no contamination above 1 mR/h was observed in CPP-79-5 (CPP-1884) above a depth of about 30 ft bgs nominal.

Gamma-logging results for north to south transect wells showed shallow elevated gamma activity in CPP-79-2 and CPP-79-4. Elevated gamma readings first occur at 4904 ft elevation (about 16 ft bgs nominal) in CPP-79-2 and increase to a maximum of 25.5 mR/h at 4903.5 ft elevation (about 16.5 ft bgs nominal) and then decrease to below 1 mR/h until the deeper contamination interval was encountered. Shallow contamination was first encountered at 4900.5 ft elevation (about 20 ft bgs nominal) in CPP-79-4 (CPP-1885), with readings increasing to 371 mR/h at 4897.5 ft elevation (about 23 ft bgs nominal). Readings decreased below that depth until the deeper contamination was encountered beginning at 4,887 ft elevation (about 33 ft bgs nominal).

Gamma-logging results for CPP-28-1 (CPP-1876) and CPP-28-2 (CPP-1877) did not show elevated gamma activity in the 16- to 24-ft bgs interval, indicating that contamination from CPP-79 (shallow) did not migrate that far north.

Sampling results for CPP-79-sample-A (CPP-1881) indicate elevated Cs-137 concentrations from 0 to 20 ft bgs, increasing to 19,600 pCi/g at 16-20 ft bgs. Concentrations of Sr-90 increase to 29,200 pCi/g in the 20- to 24-ft interval. Contamination in this interval is considered part of the CPP-79 (shallow) release.

No listed RCRA constituents were detected in the CPP-79 (shallow) zone.

5.16.5 Contamination Remaining in Alluvium

5.16.5.1 Nature of Contamination. Table 5-43 shows radionuclide analytical results for CPP-79-sample (CPP-1881 and -1882). Shallow contamination observed at about 16-28 ft bgs at CPP-79 (shallow) appears consistent with the conceptual model of the release described previously as low-activity PEW evaporator feed solution.

I-129 was not detected. Tc-99 occurred at a maximum concentration of 65 pCi/g in the 24- to 28-ft bgs interval, apparently as a result of migration from the 16- to 20-ft bgs interval. Both radionuclides are accounted for in the source term described previously. INTEC liquid waste system RCRA listed constituents analyzed for were not detected.

5.16.5.2 Vertical Extent. Contamination observed at CPP-79 (shallow) appears confined to a layer roughly 16 to 28 ft bgs, based on gamma-logging and sampling results. Sr-90 migrated below the depth of the release at about 16-20 ft bgs to at least the 24- to 28-ft interval based on sampling results at CPP-79-Sample-A (CPP-1881).

5.16.5.3 Areal Extent. Contamination at CPP-79 (shallow) appears bounded on the west by Probehole CPP-79-10 (CPP-1883), on the east by Probehole CPP-79-5 (CPP-1884), on the south by the CPP-604 vault, and on the north by CPP-28-1 (CPP-1876) and CPP-28-2 (CPP-1877).

5.16.5.4 Remaining Curies. A large fraction of the estimated 2.6 Ci of Cs-137 and Sr-90 released at CPP-79 (shallow) appears to be retained in the alluvium, primarily in the 16- to 24-ft bgs soil interval. Lesser amounts of H-3, Tc-99, and I-129 that appear in the release inventory have likely migrated beyond the alluvium into underlying basalt.

5.16.6 Uncertainties/Data Gaps

No data gaps remain for this site. The extent, distribution, and composition of the contamination observed at CPP-79 (shallow) in the 16- to 24-ft bgs interval are adequately bounded for BRA and FS purposes.

Table 5-43. Summary of analytical results for CPP-79-sample.

Depth (ft bgs)	Cs-137 (pCi/g)	Sr-90 (pCi/g)	Pu-238 (pCi/g)	Pu-239/240 (pCi/g)	I-129 (pCi/g)	Tc-99 (pCi/g)	Nitrate-N (mg/kg)	Hg (mg/kg)	Am-241 (pCi/g)	Eu-154 (pCi/g)	U-233/234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Np-237 (pCi/g)	pH	H-3 (pCi/g)	Pu-241 (pCi/g)	Fluoride (mg/kg)	Zirconium (mg/kg)
0-4	30	20	0[a]	ND[b]	ND	3	1	0.02	0	ND	2	0	1	ND	9.0	ND	—[c]	—	—
4-8	53	48	0	0	ND	2	1	0.02	0	ND	1	0	1	0	9.1	ND	—	—	—
8-12	78	76	0	0	ND	1	1	0.02	0	ND	1	0	1	0	9.0	ND	—	—	—
12-16	110	38	1	0	ND	1	1	0.02	0	ND	1	0	1	ND	8.9	ND	—	—	—
16-20	19,600	25,900	21	6	ND	33	3	0.05	6	123	1	0	1	0	8.9	ND	91	2	14
20-24	0	29,200	ND	ND	ND	22	3	0.03	ND	ND	1	0	1	ND	8.5	ND	—	—	—
24-28	0	13,400	ND	ND	ND	65	1	0.02	0	ND	1	0	1	0	9.0	ND	—	—	—
28-32	0	9	0	0	ND	19	1	0.06	0	ND	2	0	1	0	9.2	ND	—	—	—
32-36	3,350,000	219,000	(21,100)[d] 34,300	(8,800) 34,300	ND	182	1	7.61	2,330	2,860	316	ND	ND	(468) 48.5	9.0	ND	18,700	2	32
36-40	1,770	60,100	15	8	ND	15	0	0.01	ND	0	1	0	1	0	8.3	ND	—	—	—
40-44	455	6	1	1	ND	4	4	0.02	ND	0	1	0	1	ND	8.9	ND	—	—	—
44-46	300	10	1	0	ND	2	9	0.03	ND	0	1	0	1	ND	8.7	ND	—	—	—
44-46	301	8	1	0	ND	3	8	0.03	ND	0	1	0	1	0	8.7	ND	—	—	—
48-52	293	126	1	0	ND	3	7	0.03	ND	0	1	ND	1	ND	8.9	ND	—	—	—
52-56	31	25	0	0	ND	2	5	0.02	ND	ND	1	0	1	0	8.9	ND	—	—	—
56-60	1,350,000	34,700	10,700	14,600	ND	13	6	0.06	773	773	334	ND	ND	(70) 97	8.9	ND	613	5	18

a. 0 = Compound detected at less than 0.05 (decimal places not shown). For uncertainty and more analytical details, see Appendix G.
b. ND = nondetect (U) or false positive (UJ).
c. — = not analyzed.
d. Analysis was performed twice on separate aliquots from the same sample at the project's request. The number in parentheses is the original sample result followed by the second number from the second analysis.

5.16.7 References

DOE-ID, 2004, *Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/ Feasibility Study Work Plan*, DOE/ID-10676, Rev. 1, U.S. Department of Energy Idaho Operations Office, June 2004.

INEL, 1995, *Report of the 1993/1994 Tank Farm Drilling and Sampling Investigation at the Idaho Chemical Processing Plant*, INEL-95/0064, Idaho National Engineering Laboratory, Lockheed Idaho Technologies Company, February 1995.

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WINCO, 1987, Unusual Occurrence Report, WIN-86-0034-CPP, Westinghouse Idaho Nuclear Company, Inc, December 28, 1987.

WINCO, 1993, *Track 2 Summary Report for Operable Unit 3-07 (Tank Farm Area 1)*, Rev. 2, Westinghouse Idaho Nuclear Company, Inc., May 1993.

5.17 CPP-79 (Deep)

Site CPP-79 (deep) is a site that was discovered below CPP-79 (shallow) during previous drilling activities when Borehole CPP-79-1 drilled into some high-activity soil and stopped. This site has been further investigated under OU 3-14.

5.17.1 Description of Release

Recent (1992 and 2004) soil sample analyses detected a deep layer of contamination in both the CPP-79 and CPP-28 sites, below the depth of each site's historically described (relatively shallow) contamination zones. As described in DOE-ID (2004), the deep contamination in CPP-28 and CPP-79 is not associated with the shallow contamination. The CPP-28 deep contamination is at the same elevation (about 30 ft below the surface of the tank farm) as the deep contamination in CPP-79. Sites CPP-28 and CPP-79 are near each other. The piping system responsible for the CPP-79 (deep) contamination had a tile encasement that likely leaked in multiple locations. That piping system ran within 5 ft of the CPP-28 borehole location where the deep contamination was found and likely caused that contamination as well. Therefore, references to the CPP-79 (deep) contamination source term, volume of waste released, etc. in this report also apply to the deeper contamination that was discovered below Site CPP-28, which is part of CPP-79 (deep).

There are no historical reports documenting the leak(s) that caused the CPP-79 (deep) contamination. It was discovered during the 1990s tank farm upgrade project and recent soil sampling activities. The contamination scenario described in this report is based upon an evaluation of historical operating data, equipment configuration, recent contaminated soil sample analyses, and process knowledge. The contamination at CPP-79 (deep) likely occurred during three waste transfers from the CPP-604 tanks to the tank farm during 1967 (one transfer) and 1973 (two transfers). During those transfers, waste leaked from failed flange gaskets in Valve Boxes A3A and A3B. Some of that waste entered split tile pipe encasements that penetrated the bottoms of the valve boxes. The waste leaked from the tile encasements into the soil in a nearly horizontal portion of the piping located about 30 ft below the surface of the tank farm, causing the CPP-79 (deep) contamination site. The leaks went unnoticed because they were too small to have been detected by the waste monitoring systems that existed at the time.

No historical records identify the leaks that contaminated the CPP-79 and CPP-28 deep areas. Therefore, this report provides a considerable amount of detail regarding the design and configuration of the CPP-604 tank and piping system, the historical use of that system, and the 2004 contaminated soil sample data to present the basis for the estimates of the amount of waste leaked and its source term.

5.17.1.1 Background of System Configuration and Leak. To understand the basis for the estimate of the leaks that caused the CPP-79 (deep) contamination, some knowledge of the configuration and history of the CPP-604 waste tanks is necessary. The original configuration of the high-level (first-cycle) liquid waste storage system included three 18,000-gal tanks (WM-100, -101, and -102), which were located in two underground tank vaults on the north end of CPP-604. High-level waste was sent from the fuel reprocessing building (CPP-601) to the three CPP-604 waste tanks for interim storage before being transferred to the large, 300,000-gal storage tank WM-180. Stainless-steel waste transfer lines encased in split tile pipe were used to transfer waste from the CPP-604 tanks to WM-180.

Due to its early success, the SNF reprocessing program and its associated waste storage system were expanded. A major project was completed in 1955 that installed three new 300,000-gal waste storage tanks (WM-182, WM-183, and WM-184) and three new valve boxes (A2, A3A, and A3B) north of CPP-604. The new valve boxes connected the original CPP-604/tank farm waste transfer lines to the

three new tanks. The new configuration continued to use the original waste transfer system that sent waste from CPP-601 to the CPP-604 tanks and from the CPP-604 tanks to the 300,000-gal tanks. Figure 5-41 shows the configuration of some of the transfer lines and valve boxes associated with the CPP-604 tanks.

Figure 5-41 shows two tile-encased lines (colored orange) that exit the north end of the CPP-604 tank vault. The westernmost tile-encased line in Figure 5-41 came from WM-102. The line exited the vault nearly 30 ft below the tank farm surface, turned, and ran vertically to near the tank farm surface elevation where Valve Box A3A was located. The line then went back down to its original elevation 30 ft below the tank farm surface, turned, and went to WM-180. Another piping system (not shown on Figure 5-41) was located about 20 ft west of the WM-102 transfer piping system. That system was identical to that of WM-102 and contained the WM-101 discharge piping and Valve Box A3B. The convoluted piping system (long, u-shaped, vertical loop) was part of the original design and provided relatively easy access to the piping to make future connections, such as occurred in 1955.

Valve Boxes A3A and A3B were not part of the original design but were added in the 1955 expansion project. They were constructed on top of the original transfer lines, with the original lines entering and exiting the bottom of the valve box. Additional lines (not shown on Figure 5-41) penetrated the sides of the valve boxes and went to the new tanks. The valve boxes were equipped with a stainless-steel drip pan (liner) with a drain line that led to the PEW evaporator feed collection tank, WL-102 (see Figure 5-41). The valve box liner was not welded or connected to the transfer piping that entered/exited the bottom of the valve boxes. Instead, the liner had a collar, or lip, 2-3 in. high, that surrounded the lines where they penetrated the bottom of the valve box. This configuration was designed to collect leaking solution in the drip pan and direct it to WL-102.

The piping configuration of Valve Boxes A3A and A3B, with their tile-encased lines entering and exiting the bottom of a valve box, was unique to a handful of valve boxes installed with the 1955 tank farm upgrade and led to the CPP-79 (deep) contamination. Waste leaked from valve flanges in Boxes A3A and A3B due to deteriorated flange gaskets. By design, the leaking waste should have been collected in the stainless-steel liner that drained into WL-102. However, two situations allowed some leaking waste to exit the box via the tile pipe encasements that penetrated the bottom of the valve box. A plugged drain line in Box A3A caused leaking solution to collect in the box liner until it overflowed the collar surrounding the transfer lines and flowed into the tile encasements that entered the bottom of the valve box. In addition, some of the leaking solution in A3A and A3B likely fell directly into the annular gap between the transfer line and the collar surrounding the transfer line because the leaking valves were above the penetrations in the valve box floor. In these two ways, leaking waste left the valve boxes and entered the tile encasements entering the floor of the valve boxes.

Once inside the tile encasements, the leaking solution fell about 30 ft into a nearly horizontal portion of the encasements that ran north and south between CPP-604 and WM-180. The tile encasements were designed to drain to a sample box (shown on Figure 5-41) located on the north end of the CPP-604 tank vault. The sample box had a drain line that went into the stainless-steel-lined CPP-604 tank vault where it could be detected. Construction of Valve Boxes A3A and A3B in 1955 on top of the original transfer lines may have caused dirt or other construction debris to fall into the tile encasements and plug the encasement drain lines leading into the CPP-604 tank vault. This compromised the leak detection system and caused the liquid in the encasements to leak from the encasements into the soil instead of draining into the CPP-604 tank vault.

The tile encasements were not a superior design. The tile pipe was brittle and susceptible to cracking due to soil settling. In addition, the caulking used to seal the tile pipe joints was not resistant to nitric acid, a primary component of tank farm waste. The 1955 project excavated the area north of CPP-604 near the lines associated with Box A3A. That project installed the junction box (JB-2B) shown

on the tile-encased line leading to Tank WM-181 (see Figure 5-41). Such construction in close proximity to tile-encased lines likely resulted in some soil settling and subsequent cracking of the tile encasements.

The tile encasements may have had more than one crack and potential leakage points along their paths. Waste leaking into the tile encasements likely traveled several feet in the near-horizontal section of piping nearly 30 ft below grade and leaked from several points. The transfer line from WM-102 ran north from CPP-604 through the areas covered by Sites CPP-79 and CPP-28. Leakage from several locations along this path resulted in the deep contamination layers found in both CPP-79 and CPP-28. Alternatively, leakage from a single point could have been conducted via the sand bed used beneath the transfer lines several feet from the original leak location and contaminated areas within both CPP-79 and CPP-28.

5.17.1.2 CPP-604 Piping Use and Leakage Period Determination. Because there are no historical reports of the leak(s) that caused the CPP-79 (deep) contamination, estimates of the number of leaks that occurred and the volume of waste that leaked were made. This required an evaluation of the frequency of use of the CPP-604 waste transfer system, the types of waste it stored, etc.

During the early and mid-1950s the only waste route into the 300,000-gal tanks was via the CPP-604 tanks and their associated piping. Consequently, the CPP-604 tank piping was regularly used for waste transfers during that time period. Steam-powered jet pumps provided the motive force to transfer waste from the CPP-604 tanks to the 300,000-gal tanks. The jet pumps had no moving parts and thus needed no maintenance, an advantage in a radioactive environment. However, use of the jets added steam condensate to the waste, which increased the volume of the waste by approximately 10% for transfers made from the CPP-604 tanks. This was a significant disadvantage because it effectively added water to the limited tank farm storage space. Efforts were made to reduce the steam jet water to better use the limited tank farm storage space.

Accordingly, in October 1957, another major plant expansion project was completed that built two more 300,000-gal waste tanks (WM-185 and -186) and a new waste transfer system. The new waste transfer system bypassed the CPP-604 tanks and their steam jets. The new system transferred waste directly from CPP-601 to the tank farm using an airlift (WM-178), which eliminated steam jet dilution. Thereafter, the airlift was used for the bulk of waste transfers from CPP-601 to the tank farm. The CPP-604 tanks were used on a limited basis, to segregate special types of wastes (such as ROVER), or when the transfer lines in the tank farm were out of service (such as during valve maintenance).

Identifying the type of waste that leaked to the soil and correlating it with the fuel reprocessing and waste generation history of INTEC helped identify the leaks that caused the CPP-79 (deep) contamination. During its history, INTEC reprocessed a variety of SNFs. Different types of fuel generated chemically unique wastes due to differences in fuel cladding and the chemicals used in dissolving and reprocessing the different types of fuels. Detecting (or the failure to detect) these unique chemicals in the contaminated soil helped identify the source of waste and time of the leak.

Prior to 1966, virtually all waste sent to the CPP-604 or the 300,000-gal tanks came from reprocessing Al-clad fuel. In the mid-1960s, reprocessing of large quantities of Zr-clad fuel began (Al fuel reprocessing also continued). Moderate amounts of stainless-steel-clad fuel were reprocessed in the 1970s and early 1980s. Beginning in the early 1970s, most of the Zr- and Al-clad fuels were reprocessed in a “coprocessing” system that was designed to minimize waste generation. Coprocessing dissolved both Al- and Zr-clad fuels and combined the two dissolver products for subsequent uranium recovery. Each of these processes produced chemically unique wastes. For example, mercuric nitrate was used as a catalyst to dissolve Al-clad fuel. Thus, mercury (Hg) was found in Al waste but not in Zr or stainless-steel wastes. Waste from Zr fuel reprocessing contained Zr from the cladding material and fluoride (F) from the

hydrofluoric acid used to dissolve the Zr cladding. Neither Al nor stainless-steel wastes contained Zr or F. Because coprocessing waste was a combination of both Zr and Al wastes, it contained Hg, Zr, and F. The fission product content of most first-cycle wastes was similar (especially in old waste in which short-lived species had decayed), but there were differences among activation products such as the TRU components. For example, Al waste had a moderate Pu-238:Pu-239 ratio (ranging between 3 and 10). Zr waste had a much higher (over an order of magnitude) Pu-238:Pu-239 ratio than Al waste. Stainless-steel waste had a much lower Pu-238:Pu-239 ratio (over an order of magnitude) than Al waste. These unique chemical species and radionuclide ratios helped identify the sources of leaks in CPP-79 (deep), based on the 2004 soil sample analyses.

Figures 5-43 and 5-44 show the volume and type of waste stored in WM-101 and WM-102 respectively between May 1965 and January 1980, the time in which the CPP-79 (deep) contamination occurred. The waste volume varied between 0 to 18,000 gal as the tanks were filled and emptied over time. The areas beneath the volume curves are colored to show the volume and type of waste in the tanks. Figures 5-43 and 5-44 do not include data for WM-100. During the 1955 expansion project, only the transfer lines from WM-101 and WM-102 were connected with the new portion of the tank farm, leaving WM-100 connected only to WM-180. As a result, waste from WM-100 was never transferred directly to the tank farm during the suspected leak period. Instead, waste was transferred from WM-100 to WM-102 and from there to the tank farm.

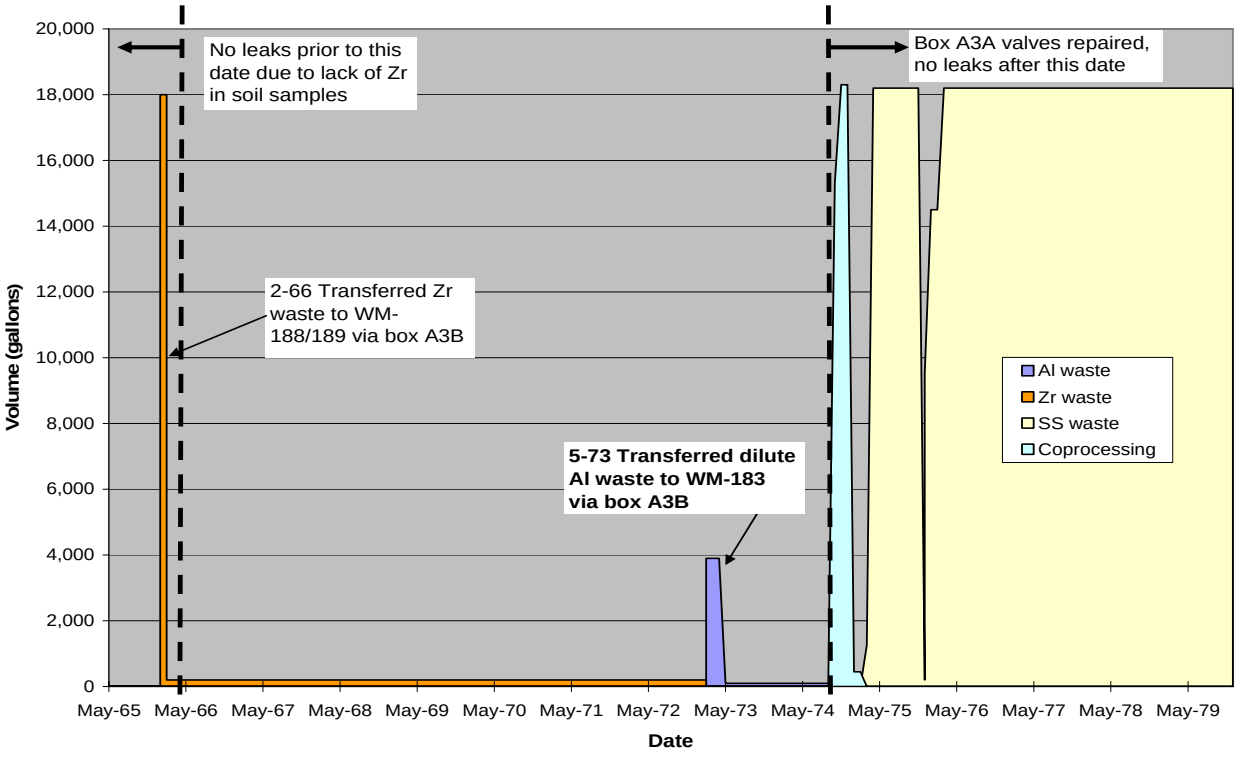

Figure 5-43. Volume and type of waste stored in WM-101 from May 1965 through December 1979.

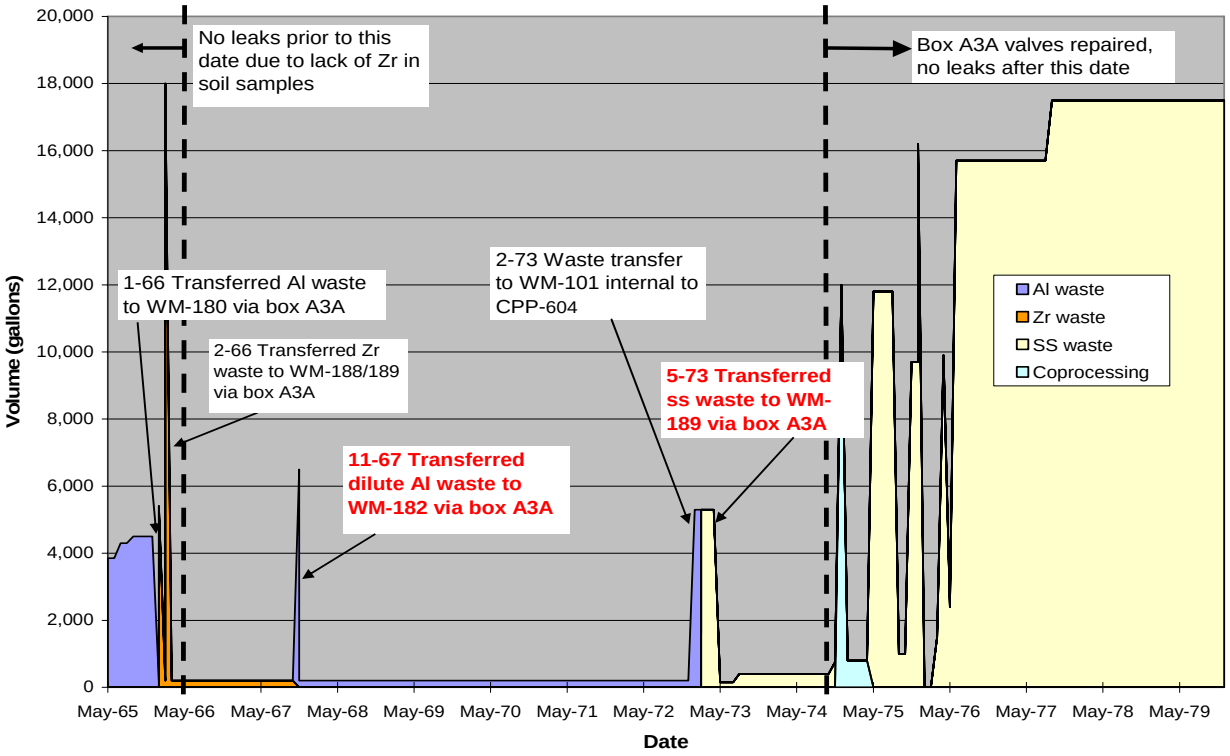

Figure 5-44. Volume and type of waste stored in WM-102 from May 1965 through December 1979.

Figures 5-43 and 5-44 each contain two dashed lines, one in 1966 and one in 1974, with text boxes indicating leaks did not occur before or after those dates. The reasons for this are as follows. In October 1974, contaminated soil associated with Site CPP-28 was discovered in an area north of CPP-604. Operations personnel conducted an exhaustive search for the cause of the CPP-28 contamination. One of the potential contamination sources was the waste transfer lines and encasements from Valve Boxes A3A and A3B. Those two valve boxes were excavated and inspected to determine if they had contributed to the CPP-28 contamination. The inspection found those boxes had not caused the CPP-28 contamination. However, the inspection found 1-2 in. of standing liquid in the stainless-steel liner of Box A3A with a radiation field of over 25 R/hr. No standing liquid was observed in Box A3B. The drain line in Box A3A was plugged (accounting for the standing liquid in A3A), whereas the A3B drain line was clear. Inspection of the flanged valves in each box found the Teflon gaskets “in a high state of deterioration” (Allied Chemical 1975). Gaskets made of Teflon fail and leak in radiation environments because Teflon becomes brittle and cracks after extended exposure to radiation. The valves were removed, refurbished, and reinstalled with gaskets that were not subject to radiation damage. The deteriorated state of the gaskets and the standing radioactive solution in Box A3A indicates leaks occurred in the valve boxes prior to October 1974.

No leaks from A3A or A3B are believed to have occurred after 1974. The new, radiation-resistant valve gaskets prevented gasket-related leaks thereafter. The tank farm waste monitoring and leak detection capabilities were significantly improved after 1974. The improved monitoring systems have shown no evidence of leaks from that piping system. The relative ratios of the radionuclides in the 2004 contaminated soil samples indicate that the leaked waste was relatively old. Radioactive waste contains both Cs-137 (half-life equal to 30 years) and Cs-134 (half-life equal to 2.1 years). The ratio of Cs-137/Cs-134 increases at a known rate over time due to the rapid decay of Cs-134. That ratio can be

used to estimate the age of a waste. The Cs-137 activity in the CPP-79 (deep) contamination layer (32 to 36 ft below surface) was about 3E+06 pCi/g. The Cs-134 activity in all the deep contamination sites was below the laboratory detection value. For the cited CPP-79 location, the Cs-134 detection value was 212 pCi/g. Use of the Cs-134 detection value results in a Cs-137/Cs-134 ratio of over 15,000. This ratio is high enough to indicate the waste in the soil came from fuel reprocessed before the 1980s, not from more "recent" waste. These data, along with the 1974 valve gasket repairs, indicate 1974 was the latest date at which leaks occurred from the CPP-604 piping system. This is shown as a dashed line on Figures 5-43 and 5-44.

Valve Boxes A3A and A3B (with their original Teflon gaskets) were installed in the 1955 upgrade project. The 1955 project excavated into the CPP-79 (deep) contamination area, but there are no reports of any contaminated soil found during that project. Therefore, the contamination occurred after that time. Although Teflon gaskets fail over time in high radiation environments, they likely lasted several years before the damage was so severe that waste leakage occurred. After 1957, when the airlift transfer system was installed, transfers out of the CPP-604 waste tanks occurred very infrequently, as shown on Figures 5-43 and 5-44. The infrequent use limited the number of potential leaks from the system after 1957.

Contaminated soil sample and waste storage history data indicate leaks did not occur before 1966. In January 1966, maintenance work was performed on valves in Box A6 during a Zr fuel reprocessing campaign. Box A6 is the junction point for the transfer route from CPP-601 to the tank farm. All waste sent to the tank farm from CPP-601 via the airlift traveled through Box A6. Fuel reprocessing operations were not stopped in January 1966 to repair the valves in Box A6. Instead, the Zr waste was sent to the three CPP-604 tanks for interim storage while the valves in Box A6 were repaired. The Zr waste was transferred from the CPP-604 waste tanks to the tank farm when the valve maintenance was complete. Figures 5-43 and 5-44 show this as an increase in the Zr waste inventory in the CPP-604 tanks (the very narrow orange band in 1966), followed by a reduction to near zero when the waste was transferred to the tank farm. This was the only time prior to 1974 (when the valves inside Boxes A3A and A3B were repaired) that the CPP-604 tanks held Zr waste.

Several of the CPP-28 and CPP-79 soil samples were analyzed for Zr. Neither Cs-137 nor Zr is very mobile in soils. If any of the Zr waste leaked during the 1966 waste transfer, it would have created high levels of both Cs-137 and Zr in the contaminated soil. On the other hand, if the 1966 Zr waste did not leak, there would be no elevated levels of Zr in the contaminated soil. The deterioration of the Teflon valve gaskets was progressive with time. If the 1966 Zr waste transfers did not leak from the valves in Boxes A3A and A3B, then waste transfers made before that time would not have leaked because the valve gaskets would have been in better condition during earlier transfers. Thus the presence or absence of Zr in the contaminated soil can be used to establish leak dates.

In the late 1960s and early 1970s, typical Zr waste contained about 1E+12 pCi/L (1 Ci/L) Cs-137 and 37,000 mg/L (0.4 M) Zr. Decaying the Cs-137 in the 1966 Zr waste to the present time (38 years) leaves about 42% of the original Cs-137 remaining today, or 0.42E+12 pCi/L. The Zr:Cs137 ratio of the 1966 Zr waste would be 8.8E-08 mg Zr/pCi Cs-137 if measured today. This would be the Zr/Cs-137 ratio in the CPP-79 (deep) contamination if it contained 1966 Zr waste. The Cs-137 activity from the 2004 CPP-79 (deep) soil samples was about 3E+06 pCi/g of soil. Multiplying the Cs-137 activity in the contaminated soil by the Zr/Cs-137 ratio from the 1966 Zr waste (decayed to the present time) results in an expected Zr concentration of 0.260 mg per gram of soil, or 260 mg/kg. The Zr in the analyzed soil samples (from shallow and deep sites in both CPP-28 and CPP-79) ranged from 15 to 30 mg/kg and had no correlation with the Cs-137 activity. The Zr content of the contaminated soil was an order of magnitude below the value expected from Zr waste contamination and appeared to be the normal Zr content of the tank farm soil. In addition, Zr waste had a very high Pu-238:Pu-239 ratio

(approximately 75:1). The ratio of Pu-238:Pu-239 in CPP-79 (deep) was approximately 1:1. Some of the soil samples even had more Pu-239 than Pu-238. Such Pu ratios did not come from Zr waste; instead, they indicate the waste came from stainless-steel fuel. The contaminated soil data show the 1966 Zr waste transfer did not leak to the soil; thus, Al waste transfers prior to that time also did not leak. This accounts for the dashed line on Figures 5-43 and 5-44 in 1966 as the earliest date at which leaks occurred.

The 1974 inspection of Valve Boxes A3A and A3B found evidence of past leaks from valve flanges due to deteriorated Teflon gaskets. The lack of elevated Zr levels and Pu-238:Pu-239 ratios of approximately 1:1 in the contaminated soil indicate the leaks did not occur before 1966. Therefore, leaks occurred in Valve Boxes A3A and A3B between 1966 and 1974 (the two dashed lines on Figures 5-43 and 5-44) that led to the CPP-79 (deep) contamination. There were only three waste transfers from the CPP-604 waste tanks to the tank farm during that time period, one from WM-101 and two from WM-102. Figure 5-44 shows three transfers were made from WM-102, but one of them went to WM-101 through CPP-604 internal piping, not to the tank farm. Text boxes on Figures 5-43 and 5-44 note the three transfers that potentially leaked with red lettering.

5.17.1.3 Waste Source Term. Defining a single waste source term for CPP-79 (deep) from historical operating data is difficult because there were multiple leaks of varying types of waste, and the relative amount of each waste type in each waste transfer is uncertain. Historical operating data show the waste that leaked definitely included first-cycle stainless-steel waste, and likely included first-cycle Al waste, second-cycle waste, and PEW. Each of the CPP-604 waste tanks also had a small amount of Zr waste residue from 1966 when they stored first-cycle Zr waste. The 1967 Al waste in WM-102 included second-cycle raffinate that had been recycled through the first-cycle extraction system as part of a Np-237 recovery process that operated for a few years at INTEC. The 1973 Al waste in WM-101 likely included some PEW that was normally sent to the PEW evaporator but had been recycled through the first-cycle extraction system for uranium recovery. The second-cycle and PEW wastes had less activity than typical first-cycle raffinate. The 1973 WM-102 waste was primarily first-cycle raffinate from stainless-steel-clad fuels.

Leaks of varying solutions caused the different chemical and radionuclide ratios seen in the 2004 soil samples. The 32- to 36-ft sample from CPP-79 contained a high amount of Hg (7.61 mg/kg), compared with the background soil concentration (0.02 mg/kg). The Cs-137 at that elevation was 3.35E+06 pCi/g, or 3.35E+09 pCi/kg. This yields a Cs-137/Hg ratio of 4.4E+08 pCi/mg. Typical first-cycle Al raffinate contained about 1 Ci/L (1E+12 pCi/L) Cs-137 and 2,000 mg/L Hg. Assuming the site is contaminated with “old” waste in which one-half of the Cs-137 has decayed, the current Cs-137/Hg ratio of the waste would be 2.5E+08 pCi/mg, which is close to that of the contaminated soil sample. Thus, the contamination shows evidence of first-cycle Al waste. The deep contamination sites have elevated activities of Pu-239 compared to Pu-238. The 56- to 60-ft CPP-79 sample contained more Pu-239 activity than Pu-238 activity. Waste from stainless-steel fuel was the only waste that contained more Pu-239 activity than Pu-238; thus, the deep contamination shows evidence of stainless-steel waste. The soil contamination data correlate with the types of high-activity wastes stored and transferred through the CPP-604 tanks in the late 1960s and early 1970s.

The information on the amount of each type of waste stored in the CPP-604 tanks in the late 1960s and early 1970s is sketchy. Instead of generating multiple radiological source terms for each of the various wastes that leaked based upon sketchy data, two source terms were developed based on the ratios of Pu-238:Pu-239/240 found in the two most highly contaminated CPP-79 soil samples, those at the 56-60 and 34-36 ft below grade surface (see Appendix E). The Pu isotope ratios varied significantly among different types of fuels (and consequently their wastes) and can be used to estimate the portion of each type of waste in a mixture of wastes.

The first source term used the Pu ratios from the 56- to 60-ft (below grade) soil sample. That waste had a volumetric composition of 66% first-cycle stainless-steel waste and 34% first-cycle coprocessing waste. A second source term for CPP-79 (deep) was developed based upon the Pu ratios in the 34- to 36-ft (below grade) soil sample. That sample had a high Hg content, so the source term was developed for a stainless-steel/Al waste blend. The second source term had the volumetric equivalent of 62% stainless-steel waste and 38% Al waste. In general, both source terms are similar because the waste mixtures were similar, both consisting of nearly 2/3 stainless-steel waste. Both source terms fit the waste storage tank history with the dominance of the stainless-steel waste.

For long-lived fission products, the two CPP-79 source terms are virtually the same, since fission product activity is related to the age of the waste, not the type of fuel from which it was derived. However, the activation products of the two source terms vary due to differences in the types of fuels from which the waste is derived. This difference was generally a factor of two or less. In general, the first source term has more Co-60 and Pu-239, and the second source term has more Np and Am.

The two source terms for CPP-79 (deep) do not vary significantly in fission product content, and the variation in activation products is typically a factor of two or less. Without any quantitative data on the amounts of each waste type released at CPP-79 (deep) there is no way to reliably assign portions of the waste that leaked to either source term. Therefore, instead of arbitrarily assigning portions of the waste to each source term, this report uses the first source term (56- to 60-ft elevation) for all of the CPP-79 (deep) activity. This provides a worst-cast activity for Pu-239, which may be the most significant COC. The activity of the major fission products of concern (based upon the 56- to 60-ft sample) is shown in Table 5-44. The source term is based upon a Cs-137 activity of 0.619 Ci/L in 1973. This Cs-137 activity is conservatively high, because it assumes all the waste was first-cycle waste. Some of the waste that leaked was PEW and second-cycle wastes, which contained less activity than first-cycle waste. Details concerning the derivation of the source term are in Appendix E.

The nitrate concentration of the CPP-79 waste varied between 3.5 and 4.5 M for the bulk of the wastes that leaked, first-cycle Al and stainless-steel raffinates, as well as second-cycle waste. A value of 4.0 molar is a reasonable average for such wastes and it is included in Table 5-44.

Table 5-44. Estimate of major radionuclides and nitrate in the waste released at CPP-79 (deep).

Cs-137	Sr-90	H-3	Tc-99	I-129	NO_3
0.62 Ci/L	0.58 Ci/L	3.5 mCi/L	0.099 mCi/L	0.24 μCi/L	4.0 molar

5.17.1.4 Waste Volume Leaked to Soil. A detailed review of the waste transfers that potentially leaked (see Figures 5-43 and 5-44) resulted in an estimated release of 400 gal of waste. This estimate is at the lower end of the range of the estimate made in DOE-ID (2004). It is fairly certain the release was small (a few hundred gallons) because there were very few transfers that potentially leaked and the transfers were small (which limited the potential leakage). The leaked volume was not large enough for a volume discrepancy to have been noted in any historical reports. Calculations and assumptions for the release volume estimates are in Appendix E of this report. The calculations assume the average jet dilution for first-cycle waste transfers from CPP-604 to the tank farm was 10%. The difference between the average (10%) jet dilution and the measured value is the estimate of the waste released. For example, if 1,000 gal of waste were transferred, 100 gal was the expected (10%) jet dilution. If the transfer data showed the jet dilution was only 70 gal, then the assumed leak was 30 gal. Due to variability in the jet dilution, the CPP-79 leaks could have been a few hundred gallons more or less than the 400-gal estimate. The volume estimate is probably accurate to within a factor of 50%.

Steam jet dilution varied depending on parameters such as steam pressure, waste density, and piping configuration. The 1966 transfers of Zr waste from CPP-604 to the tank farm did not leak and had an average jet dilution of 10% (see calculations in Appendix E). The 1966 Zr waste transfers had similar characteristics (solution density, piping configuration, etc.) to those that leaked. This provides confidence in use of the 10% jet dilution factor to estimate the release. Although the leak estimate has considerable uncertainty, it is reasonably certain that the leaks were a few hundred (not thousand) gallons.

5.17.1.5 Source Term Summary. The source of the CPP-79 (deep) contamination was determined by a review of historical operating data, piping configurations, and 2004 contaminated soil data to have been leaks from failed valve flange gaskets in Boxes A3A and A3B in the 1960s and 1970s. Some of the leaking solution went into the tile pipe encasements that penetrated the floors of the valve boxes and fell into a nearly horizontal portion of encasement approximately 30 ft below the tank farm surface. The waste leaked into the soil through cracks and joints in the tile encasements. The tile encasements likely leaked at multiple locations along its north/south run and thus contaminated the deep area in both the CPP-79 and CPP-28 sites.

Table 5-45 summarizes the activity of the major radionuclides and mass of nitrate released at Site CPP-79 (deep), assuming a release of 400 gal of waste with the source term given in Table 5-44.

Nearly 1,000 Ci of Cs-137 were released at Site CPP-79 (deep). Although this represents a significant release of radioactivity, it is a relatively small portion (less than 10%) of the entire tank farm source term, which includes nearly 17,000 Ci of Cs-137 at Site CPP-31. Thus, some uncertainty in the estimates of activity for CPP-79 (deep) should not significantly impact groundwater models.

Table 5-45. Estimate of major radionuclides and nitrate released at CPP-79 (deep) from three releases totaling 400 gal of waste.

	Cs-137	Sr-90	H-3	Tc-99	I-129	NO_3
CPP-79 (deep)	940 Ci	870 Ci	5.3 Ci	0.15 Ci	3.6E-04 Ci	380 kg

5.17.2 Cleanup

CPP-79 (deep) contamination begins at an elevation of about 4,886 ft, so the 1993-1994 CPP-79 (shallow) excavation likely did not remove significant contamination from CPP-79 (deep). No other records have been found of any removal of contaminated soil from CPP-79 (deep); therefore, no contamination is assumed to have been removed.

5.17.3 Previous Investigations

Specifics of the previous limited CPP-79 (deep) investigation are discussed below.

5.17.3.1 Site CPP-79 (Deep) Investigation and Leak Description. One soil boring, CPP-79-1, was installed near the CPP-79 release site (see Figure 5-40) on a berm approximately 8 ft above the ground surface of the tank farm. The soil sample collected from 33.5 to 34 ft bgs had significantly higher levels of radiation than shallower samples and, at the time, was too radioactive to be analyzed by either on-Site or off-Site analytical laboratories. This sample had a contact surface radiation level of 400 mR/hr beta-gamma. (This radiation level is considerably lower than the 400 R/hr value presented in the Track 2 Summary Report for Operable Unit 3-07 [WINCO 1993] and the OU 3-14 Tank Farm Soil and Groundwater Phase I RI/FS Work Plan [DOE-ID 2000].) After careful review of the CPP-79 field logbook, the highest measured radiation level was determined to be 1.2 R/hr, which was measured from

a sample collected from the 32- to 33.3-ft depth interval at the open end of the split-spoon sampler. Subsequent measurements taken in the laboratory where the split-spoon sampler was disassembled under controlled conditions ranged from 400 to 800 mR/hr beta-gamma and 200 to 300 mR/hr beta. The values documented in the logbook (mR/hr) were reported in subsequent documents as R/hr, leading readers of the reports to believe there was extremely contaminated soil at CPP-79. The sample collected from the 33.5- to 34.0-ft interval was disposed down the borehole near the depth from which it originated.

The radionuclide analysis of the sample collected from 32 to 32.5 ft bgs measured significantly higher gross alpha (8.09E+05 ±9.71E+04 pCi/g) and beta (1.89E+07 ±1.52E+06 pCi/g) activities than were measured in sample intervals above 24 ft bgs. Isotopic analysis of this soil also detected significantly higher concentrations of Cs-137 activities (3.37E+07 ±1.06E+06 pCi/g), Sr-90 (5.41E+06 ± 4.91E+03 pCi/g), Pu-238 (2.76E+05 ± 5.52E+04 pCi/g), Pu-239 (8.99E+04 ± 1.79E+03 pCi/g), and Am-241 (1.66E+04 ± 2.18E+03 pCi/g) than in shallower sample intervals. The isotopic plutonium results for the samples collected at CPP-79-1 were originally reported as unusable in the *Track 2 Summary Report for Operable Unit 3-07 (Tank Farm Area 1)* (WINCO 1993) due to a 0.0% yield of the chemical tracer. Inquiry to the laboratory by the SAM office found that the percent yields for sample analyses were incorrectly reported and were actually approximately 50%. Therefore, the results were considered usable and were reported in the *Report of the 1993/1994 Tank Farm Drilling and Sampling Investigation at the Idaho Chemical Processing Plant* (INEL 1995). The analysis led investigators to conclude that the deeper contamination is not from the low-activity PEW evaporator waste associated with Site CPP-79 (shallow). The revised conceptual model of contributing sources to the deeper zone of contamination is discussed in Section 5.17.1.

5.17.4 OU 3-14 Investigation

5.17.4.1 Scope. The OU 3-14 field investigation focused on resolving remaining data gaps for CPP-79 (deep) described below. Details of the OU 3-14 field investigation at CPP-79 (deep) are provided in Appendix H. These include

- Sample collection procedures
- Sample documentation, custody, handling, and transportation
- Analytical methods
- Data reporting
- Quality control.

Details of the location and installation of gamma-logging probeholes and sampling coreholes are provided in Appendix F.

5.17.4.2 DQOs. DQOs for the OU 3-14 field investigation for CPP-79 (deep) are summarized in Table D-16 of DOE-ID (2004). The extent, distribution, and composition of contamination present were inadequately known to resolve Decision Statements 2 and 3. Specifically, the areal and vertical extent of contamination was inadequately known to identify and analyze alternatives for the FS. Additionally, the composition of contamination was considered inadequate to complete the BRA and FS, since concentrations of all COPCs, including Tc-99 and I-129 and RCRA metals and organics, had not been determined either through process knowledge or sampling and analysis. The release source was unknown; therefore, a source term and conceptual model for the release had not been determined. However, process knowledge of the source term and conceptual model, including activity of Tc-99 and I-129 present in the release, was subsequently improved, as described previously.

The field investigation strategy formulated to obtain the decision inputs needed to resolve the decision statements included

- Install six to eight probeholes N to S between CPP-28 and the tank vault wall and W to E bracketing CPP-79-1. Gamma log probeholes to determine areal extent, estimate vertical extent of initial release. Install additional probeholes as needed to bound extent.

- Collect one continuous core to basalt in the hotspot and analyze for the COPCs listed in Table 5-5. Archive excess sample material for possible subsequent K_d or treatability studies.

Probehole installation is described in Appendix F. Samples were collected in 4-ft intervals in core barrels using GeoProbe direct-push tooling and analyzed for the constituent list shown in Table 5-6. Results are summarized in Table 5-46. This table includes only a subset of analytical results and does not include laboratory or validation flags, sampling errors, or method detection limits; "ND" represents compounds that were U- or UJ-flagged; and "0" represents compounds detected at low levels but the decimal places are not shown. Complete detailed sampling results are provided in Appendix G. Casing was installed and the hole was gamma-logged using the AMP-50. Gamma readings for each depth interval are listed in Table A-1 of Appendix F.

Table 5-46. Summary of CPP-79 (deep) probehole and corehole installation.

Probehole number (Hydrologic Data Repository Name)	Date	Depth of Installation	Sampled or Gamma-Logged?	Comments
CPP-79-Sample-A (CPP-1881)	9/7/04-9/13/04	47 ft bgs	Sampled 0-47 ft bgs interval	Unable to advance 3.5-in. casing and sampling system beyond 47 ft bgs
CPP-79-Sample-B (CPP-1882)	09/15/04	58 ft bgs (to basalt)	Sampled 48-58 ft bgs interval	Used 2.125-in. sample system; lower recovery than with 3.5-in. system
CPP-79-10 (CPP-1883)	09/27/04	49.3 ft bgs (to basalt)	Gamma-logged using AMP-50 and AMP-100	None
CPP-79-5 (CPP-1884)	08/31/04	44.3 ft bgs (to basalt)	Gamma-logged using AMP-50 and AMP-100	Hand-augered to 3 ft bgs to avoid utility lines
CPP-79-4 (CPP-1885)	08/30/04	49.2 ft bgs (to basalt)	Gamma-logged using AMP-50 and AMP-100	None
CPP-79-2 (CPP-1886)	09/01/04	57.9 ft bgs (to basalt)	Gamma-logged using AMP-50 and AMP-100	None
CPP-79-6 (CPP-1887)	08/30/04	64.0 ft bgs	Gamma-logged using AMP-50 and AMP-100	None
CPP-79-8 (CPP-1888)	08/30/04	43.1 ft bgs	Gamma-logged using AMP-50 and AMP-100	None

5.17.4.3 Probing and Gamma-Logging Investigation. Six probeholes and two coreholes were installed at CPP-79 (deep) at the locations shown in Figure 5-40. Installation details are summarized in Table 5-46. Existing Probeholes A-61, A-62, 28-1, and 28-2 were also gamma-logged as part of the CPP-79 (deep) investigation.

5.17.4.4 Results. OU 3-14 field investigation sampling and gamma-logging results for CPP-79 (deep) are summarized in Table 5-46 and in Table B-1 of Appendix F. Table B-1 shows approximate downhole gamma readings for west to east and south to north cross sections through the CPP-79 (deep) contaminated area. Because Probeholes CPP-79-4, -6, and -10 are on or near the elevated berm over the CPP-604 vault and since the ground surface is somewhat irregular in the area, both depths below the nominal tank farm ground surface elevation at about 4,920 ft, as well as elevations above mean sea level (msl), are given in the discussion below for clarity.

The western and eastern extents of contamination are bounded by Probeholes CPP-79-10 (CPP-1883) and A-62, respectively. No contamination above 1 mR/h was observed in either probehole. Elevated gamma readings (greater than 1 mR/h) were observed in Probeholes CPP-79-2 (CPP-1886) and -6 (CPP-1887) beginning at an elevation of about 4,888 ft above msl (about 30 ft bgs nominal). Gamma readings increased to a maximum of about 4,000 mR/h between 4,887 and 4,884 ft above msl (33-36 ft bgs nominal) in both probeholes. Readings declined to below 1 mR/h in both probeholes until about an elevation of 4,864 ft (about 55 ft bgs nominal) where readings increased to about 67 mR/h in CPP-79-2 (CPP-1886) and 1.5 mR/h at CPP-79-6 (CPP-1887).

Gamma readings trend lower in wells east of CPP-79-2 (CPP-1886). Maximum readings of 320 mR/h were observed at about 4,888 ft elevation (about 32 ft bgs nominal) in CPP-79-5 (CPP-1884), with readings trending to less than 1 mR/h above and below that depth. Maximum readings of 102 mR/h were observed at about 34.5 ft bgs in CPP-79-5, with readings trending to less than 1 mR/h above and below that depth. No readings greater than 1 mR/h were observed in CPP-79-10.

Gamma-logging results for Well A-61 show gamma readings less than 1 mR/h above about elevation 4,890 ft (29 ft bgs nominal). Readings increase below this depth to a maximum of 21 mR/h at elevation 4,885.5 (34 ft bgs nominal) and then decrease to 6 mR/h at the completion depth of elevation 4,881.5 (38.3 ft bgs nominal). This well is west of clean Probehole CPP-79-10 (CPP-1883); however, the observed gamma readings are indistinguishable from those observed elsewhere in the contaminated backfill used throughout the tank farm.

Results for Well A-62 show no detections above 1 mR/h from ground surface to the completion depth at elevation 4,880 ft (36.7 ft bgs nominal).

Gamma-logging results for north to south transect wells showed high gamma activity in all four wells at about 4,884 to 4,888 ft elevation (about 32-34 ft bgs nominal). Shallow contamination was first encountered at about 4,900 ft elevation (about 20 ft bgs nominal) in CPP-79-4 (CPP-1885) with increasing readings to 4,897 ft elevation (about 23 ft bgs nominal). Readings decreased below that depth until the deeper contamination was encountered beginning at 4,887 ft elevation (about 33 ft bgs nominal). Readings increased to 4,000 mR/h at 4,884.5 ft elevation (about 35.5 ft bgs nominal). Readings decreased below this depth to < 1 mR/h at completion depth at 4,876 ft elevation (about 44 ft bgs nominal).

Shallow contamination up to 14 mR/h was also observed in existing Probeholes CPP-28-2 and CPP-28-1, from elevations 4,908 to 4,904 ft above msl (about 12 to 16 ft bgs nominal). Concentrations declined in both probeholes below this depth until the deeper contamination was encountered between 4,887-4,889 ft elevation (31-33 ft bgs nominal) where readings rapidly increased to maxima of 2,330 and 2,720 mR/h in CPP-28-2 and CPP-28-1, respectively. Concentrations decreased to below 1 mR/h at

about 4,879 ft above msl (about 41 ft bgs nominal) and continued to decline to completion depths in both wells.

Sampling results for CPP-79-sample (CPP-1881/-1882) indicate elevated Cs-137 concentrations from 0 to 20 ft bgs, increasing to 19,600 pCi/g at 16-20 ft bgs. Concentrations of Sr-90 increase to 29,200 pCi/g in the 20- to 24-ft interval. Relatively lower levels of contamination in this interval are considered part of the CPP-79 (shallow) release.

Concentrations of Cs-137 and Sr-90 decrease below these intervals to 0 and 9 pCi/g, respectively, until the deeper contamination is encountered at about 32 ft bgs. Concentrations of Cs-137 (3,350,000 pCi/g) and Sr-90 (219,000 pCi/g) increase in the 32- to 36-ft interval. Increased concentrations of Pu-238 (21,100 pCi/g), Pu-239/240 (8,800 pCi/g), Am-241 (2,330 pCi/g), Eu-154 (2,860 pCi/g), and U-233/234 (316 pCi/g) also occur in the 32- to 36-ft interval.

Concentrations of Cs-137 decrease below the 32- to 36-ft interval until an abrupt increase at 56 to 60 ft bgs to 1,350,000 pCi/g at the bottom of the probehole. Concentrations of Sr-90 (34,700 pCi/g), Pu-238 (10,700 pCi/g), Pu-239/240 (14,600 pCi/g), Am-241 (773 pCi/g), and U-233/234 (334 pCi/g) also increase abruptly in this interval.

Concentrations of INTEC liquid waste system listed RCRA constituents cited in INEEL (1999) detected below the 30-ft bgs interval are provided in Appendix G. Concentrations of all listed RCRA constituents analyzed for are below detection limits.

5.17.5 Contamination Remaining in Alluvium

5.17.5.1 Nature of Contamination. Table 5-42 shows radionuclide analytical results for CPP-79-sample (CPP-1881 and -1882). Deep contamination observed at about 28-32 ft bgs in OU 3-14 and previous sampling appears consistent with the conceptual model of the release described previously as several waste types released over a period of years.

I-129 was not detected. Tc-99 occurred at a maximum concentration of 182 pCi/g in the 32- to 36-ft bgs interval. Both radionuclides are accounted for in the source term described previously.

INTEC liquid waste system RCRA listed constituents analyzed for were not detected.

5.17.5.2 Vertical Extent. Contamination observed at CPP-79 (deep) appears confined to a relatively thin layer roughly 28 to 32 ft bgs based on gamma-logging results. However, elevated levels of radionuclides appear again at 56-60 ft bgs, at the alluvium-basalt interface. These results indicate that contamination migrated into underlying basalt at this location.

5.17.5.3 Areal Extent. Contamination at CPP-79 (deep) appears bounded on the east by Probehole A-62, on the south by the CPP-604 vault, and on the west by Probehole CPP-79-10; on the north, it appears contiguous with the deep contamination observed at CPP-28 but is bounded by Tank WM-181.

5.17.5.4 Remaining Curies. A large fraction of the estimated 2,000 Ci released in 400 gal of first-cycle stainless-steel and Al waste, second-cycle waste, and PEW appears to be retained in the alluvium, primarily in the 28- to 32-ft bgs soil interval. The fraction released into basalt is unknown, but, given the relatively large areal extent of contamination resulting from a 400-gal release, the majority of the contamination released is still present in the alluvium.

5.17.6 Uncertainties/Data Gaps

Table 5-47 summarizes data gaps for CPP-79 (deep). The extent, distribution, and composition of the contamination observed at CPP-79 (deep) in the 28- to 32-ft bgs interval are adequately bounded for BRA and FS purposes. Any remaining FS data gaps regarding extent can be resolved during remedial design/remedial action.

Table 5-47. Summary of data gaps for Site CPP-79 (deep).

Decision Statements	Extent Known Adequately To Resolve Decision Statement?	Distribution Known Adequately To Resolve Decision Statement?	Composition Known Adequately To Resolve Decision Statement?	Properties[a] Known Adequately To Resolve Decision Statement?
1. Determine whether or not soil exposure risks to future workers at CPP-79 exceed allowable levels, requiring control of the exposure pathway.	NA.[b] All contamination is at depths > 4 ft bgs.	NA. All contamination is at depths > 4 ft bgs.	NA. All contamination is at depths > 4 ft bgs.	Properties information is not needed to resolve Decision Statement 1.
2. Determine whether or not contaminants are transported out of the tank farm soils to the SRPA at rates sufficient to result in COPC concentrations exceeding allowable levels at the exposure point, requiring control of the exposure pathway.	Yes. Fraction of release having entered basalt can be addressed through conservative assumptions.	Yes.	Yes. Contaminant composition consistent with conceptual model of release.	Yes. Mobility of Sr-90 remaining in alluvium is adequately known based on modeling.
3. Determine whether or not a remedial action that includes [GRA][c] best meets FS evaluation criteria to mitigate excess risks, relative to other alternatives.	Yes. Extent adequately bounded for FS.	Yes.	Yes. Contaminant composition consistent with conceptual model of release.	No. Chemical form and mobility of Sr-90 remaining in alluvium is uncertain and more data are needed to evaluate in situ treatment.

a. Properties refer to physicochemical parameters for fate and transport modeling of groundwater contamination source term and parameters needed to evaluate in situ or ex situ treatment for release sites that present significant risks to groundwater. Knowledge of properties is not needed for sites that do not pose significant groundwater risks based on the estimated fractional radionuclide mass present.
b. NA = not applicable.
c. GRAs to be evaluated include No Action, Institutional Controls, Containment (including capping), Treatment (in situ and ex situ), Retrieval, and Disposal.

The extent and distribution of the contamination observed in the 56- to 60-ft interval are uncertain. Some fraction of the source term must be assumed to have migrated to basalt and to no longer be retained in the alluvium. However, since the total CPP-79 (deep) release is estimated to comprise about 5% or less of the total tank farm release inventory, this data gap can be adequately addressed in the groundwater modeling for the BRA through conservative assumptions.

5.17.7 References

Allied Chemical, 1975, *Investigation Report ICPP Tank Farm Contaminated Soil Incident*, Document ID 27156, Alternate ID 003798, Allied Chemical Corporation, September 18, 1975.

DOE-ID, 2000, *Operable Unit 3-14 Tank Farm Soil and Groundwater Phase I Remedial Investigation/ Feasibility Study Work Plan*, DOE/ID-10676, Rev. 0, U.S. Department of Energy Idaho Operations Office, December 2000.

DOE-ID, 2004, *Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/ Feasibility Study Work Plan*, DOE/ID-10676, Rev. 1, U.S. Department of Energy Idaho Operations Office, June 2004.

INEEL 1999, *A Regulatory Analysis and Reassessment of U.S. Environmental Protection Agency Listed Hazardous Waste Numbers for Applicability to the INTEC Liquid Waste System*, INEEL/EXT-98-01213, Rev. 1, Idaho National Engineering and Environmental Laboratory, February 1999.

INEL, 1995, *Report of the 1993/1994 Tank Farm Drilling and Sampling Investigation at the Idaho Chemical Processing Plant*, INEL-95/0064, Idaho National Engineering Laboratory, Lockheed Idaho Technologies Company, February 1995.

WINCO, 1993, *Track 2 Summary Report for Operable Unit 3-07 (Tank Farm Area I)*, Rev. 2, Westinghouse Idaho Nuclear Company, Inc., May 1993.

5.18 Contaminated Backfill, Soils Inside Tank Farm Boundary, and CPP-96

Contaminated soil, which was excavated from tank farm sites, was historically reused as backfill in areas that extended outside of the original release sites in the tank farm. However, the OU 3-13 RI/FS did not adequately address the contaminated backfill. In order to ensure that the contaminated backfill was assessed, the OU 3-13 ROD identified the “interstitial soil” between the tank farm sites as part of a larger, new site identified in OU 3-14. Site CPP-96 is a consolidation of the contaminated backfill between the tank farm sites with all of the previously identified release sites within OU 3-14 that are the result of specific, historical, waste-release incidents, such as Site CPP-31 and two sites outside the tank farm boundary (CPP-15 and CPP-58). The specific sites are described in DOE-ID (2004) and elsewhere. Unlike the specific waste-release contamination sites, the amount and location of contaminated backfill in the tank farm area is not well documented or known. The radioactivity in interstitial soil is included as part of the source terms of the specific waste release contamination sites and is not an additive term to the total tank farm source term.

Construction, maintenance, modification, and other process-related activities at the tank farm and CPP-604 have required considerable soil excavation. The eleven 300,000-gal tanks in the tank farm were constructed by five major projects in the 1950s and early 1960s. Since that time, there have been numerous additional tank farm and CPP-604 process-related projects that installed and modified

underground tank vaults, tanks, waste transfer piping, utility piping, valve boxes, instrumentation, etc. Many of those projects excavated areas that had been contaminated by waste releases.

Contaminated soils from excavations were handled in a variety of methods. Highly contaminated soil was usually removed, packaged, and sent to the RWMC for disposal. Slightly contaminated soil was often used as backfill, generally in belowgrade locations, and covered with "clean" (noncontaminated) fill material. The contamination levels of soil allowed for use as backfill varied over time and with each project, so there is no contamination standard that applies to all backfill. Some projects reused contaminated soil within areas designated as contaminated sites today; others reused contaminated backfill in areas outside designated contamination site boundaries. Site CPP-96 includes the interstitial soil to ensure that this contamination, which was distributed outside of the known release sites, is assessed. The location, amount, and radioactivity of the contaminated backfill were not well documented for most projects and thus are not fully known today.

Even if all of the projects had rigorously documented the reuse and activity of contaminated soil, it would likely be inadequate for today's needs. The level of activity of concern today would likely have been considered clean soil by historical construction standards and not included in contaminated soil disposition reports. Historical construction projects typically used a HP technician equipped with hand-held instrumentation to determine the presence of soil contamination during excavation activities. The field instrumentation used to detect radioactivity was much less sensitive in detecting radioactivity than laboratory techniques and was unable to detect very low levels of activity. Also, small pockets or low levels of contamination could have been hidden by a covering of clean soil and gone undetected. Some projects likely deemed some soils clean that laboratory analyses would have found contaminated with very low levels of activity. Such soils were likely used as "clean" backfill in various locations in the tank farm area and their location is unknown today.

When contaminated soil was removed from the tank farm during construction activities and sent for disposal, the source of the backfill material came from a variety of local INTEC sources. Fill material (alluvium) was plentiful around INTEC and was usually obtained from a pit nearby the tank farm. There are several old gravel pits in the INTEC area from which fill was taken. For example, Percolation Pond 1 was originally a gravel pit. A pit in the northeast corner of INTEC has since been filled. Other pits are still visible on the west side of INTEC. Many projects generated excess soil from belowgrade construction that was stockpiled and used later at other construction sites that needed fill material. For example, material from the 1974 excavation for the APS upgrade may have been used for the new PEW evaporator cell backfill when some of that soil was sent to RWMC (Site CPP-27/33). Those two projects were in progress at the same time. The exception to all this was the occasional project, or portion of a project, that required a special type of fill. For example, the 1977 tank farm upgrade project installed an impervious plastic membrane over the top of the tank farm. That project required a small layer of screened sand placed below the membrane. This special material likely came from a source such as a commercial plant in Idaho Falls rather than a nearby gravel pit.

5.18.1 CPP-31 Contaminated Backfill Data

The 2004 tank farm soil characterization data illustrate the difficulty of estimating the amount of contaminated backfill in the tank farm based on historical contaminated soil and backfill reports. During 2004, soil samples were taken from five tank farm contamination sites and analyzed. All soil samples were surveyed for radioactivity prior to shipment to a laboratory for analysis. The survey used hand-held instrumentation similar to that used to survey historical excavation sites. The samples from the top three layers of Site CPP-31 (0-4, 6-8, and 10-12 ft below grade) had less-than-detectable gamma and beta radiation (<0.5 mR/hr) as determined by the hand-held field instrumentation. Such soils would have been deemed clean had they been part of a past excavation project and could have been used for backfill

at any location in the tank farm. However, laboratory analyses of the three CPP-31 samples found they contained Cs-137 activities of 214, 438, and 428 pCi/g in the 0 to 4-, 6- to 8-, and 10- to 12-ft samples, respectively. This shows that contaminated soil that exceeded CERCLA risk-based levels was likely not detected during historical excavations and could have been used as "clean" backfill in the tank farm. The location and extent of such soils are unknown.

The 2004 sample point for Site CPP-31 was located a few (5 to 6) feet west of Valve Box C-15. Valve Box C-15 was constructed in 1977 during a major tank farm upgrade project. It is approximately 7 ft square and extends approximately 13-14 ft below grade. Construction of Valve Box C-15 likely excavated the upper portion of Site CPP-31 from which the 2004 samples were taken. Thus, the three upper CPP-31 samples (having the low-activity contamination) are backfill from that project.

Figure 5-45 is a photograph of construction activity in the tank farm during the 1977 tank farm upgrade project and shows some of the extensive trenching and excavation work that occurred. The picture was taken from a point north of WM-180 and west of Valve Box C-8, near the western intersection of contamination sites CPP-31 and CPP-16. The photo was taken looking east. Most of the area visible on the left-hand side of the photo is in Site CPP-31. Site CPP-16 occupies the foreground on the right-hand side. The middle and background on the right-hand side are not in any contamination site (except CPP-96). The photo illustrates the degree of trenching and excavation that occurred during the 1977 project. Several piles of soil can be seen in the background. Some of the trenches ran through both designated contamination sites and areas that are outside the contamination sites. Soils from both areas were piled together (if deemed clean) and then reused to backfill the trenches. Soils that originated in contamination sites and had very low levels of activity (less than field-detection limits) were likely used as "clean" backfill in other areas, thus spreading low-level contamination.

The presence of laboratory-detectable activity that is less than field-detectable activity in the CPP-31 soil samples and the extent of the excavation shown in Figure 5-45 illustrate the difficulty of identifying the amount of contaminated backfill from historical soil disposition records. It also shows that soils containing very low levels of activity could have been used as backfill virtually anywhere within the tank farm.

5.18.2 CPP-27 Contamination Site and Contaminated Backfill Data

DOE-ID (2004) discusses the low-level soil contamination found in 1992 in various boreholes located north of the main stack and east of CPP-604 in Site CPP-27. The 2004 soil sampling effort found contamination in Borehole CPP-27-1 at elevations similar to those of the 1992 samples. Figure 5-46 (originally Figure 3-25 in DOE-ID [2004]) shows this area, including location of the CPP-27 release, the CPP-27 contamination site, a 1983 excavation, a 1974 excavation, and various soil sample boreholes. DOE-ID (2004) attributes the shallow contamination in some of the boreholes to contaminated backfill from the 1983 excavation. However, it indicates the source of the deeper contamination in some boreholes and all the contamination in CPP-27-1 is unknown because it is outside the boundary or too deep to be from the 1983 excavation.

Regulatory Agency personnel expressed an interest in the source of the CPP-27-1 contamination during December 2004 meetings on the tank farm soil contamination. DOE-ID (2004) hypothesizes that the contamination may have come from an unknown leaking line, seepage from the stack, etc. and indicates the need for further investigation to identify the source of the contamination. Based upon further investigation, the most likely source of the contamination in CPP-27-1 is the use of contaminated backfill from a 1974 construction project. The contamination in Borehole CPP-27-1 also illustrates the difficulty in determining the amount and location of contaminated backfill in interstitial soil from historical information.

Figure 5-45. Construction photograph from the 1977 tank farm upgrade project showing the forms for Valve Box C-8 with trenching in contamination sites CPP-31 and CPP-16.

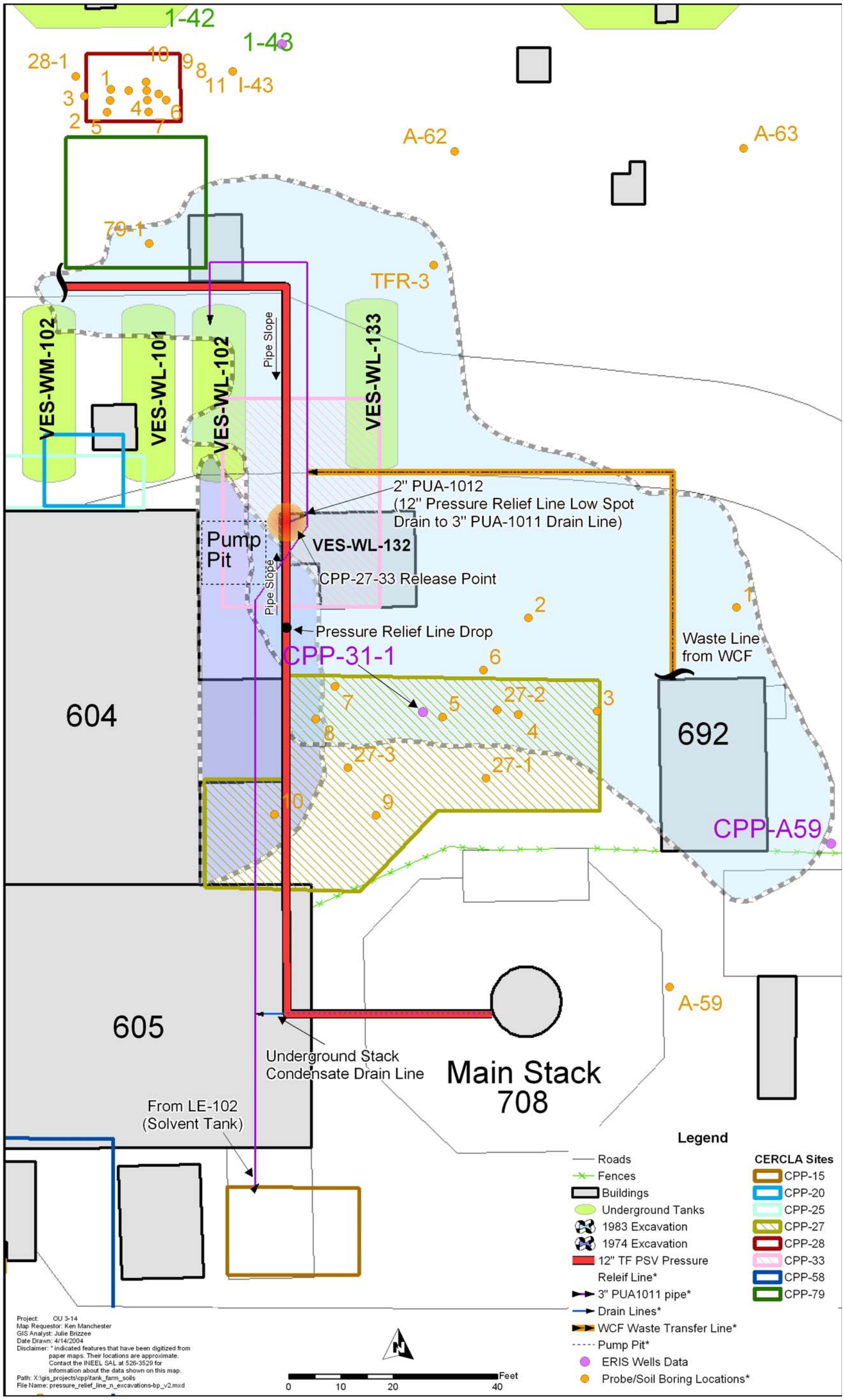

Figure 5-46. Schematic of contamination area east of CPP-604 and north of the main stack generated from photographs taken before the excavations were at their maximum extent. Haul road through CPP-27-1 is not shown.

Borehole CPP-27-1 is approximately 41 ft north of the centerline of the main INTEC stack (CPP-708) and 34 ft east of the new CPP-604 PEW evaporator cell that was built in 1974. The 2004 soil sampling effort found Cs-137 activities of 40 pCi/g in the 6- to 8-ft (below grade elevation) sample, 25 pCi/g in the 10- to 12-ft sample, and 268 pCi/g in the 14- to 16-ft sample. Figure 5-46 shows the 1974 excavation as a relatively narrow area along the eastern edge of CPP-604 and the CPP-27 contamination site as a large area, extending east from CPP-604 past the northern side of the main stack. Borehole CPP-27-1 is within the CPP-27 contamination site but not within the 1974 (or any other) excavation/backfill area shown on Figure 5-46. Research subsequent to DOE-ID (2004) has determined that Figure 5-46 does not accurately reflect the 1974 excavation or original spread of the CPP-27 contamination.

The 1974 CPP-27 contamination incident report, Allied Chemical (1974), gives no indication that activity from the waste release was in the area of Borehole CPP-27-1. The report indicates waste leaked from a 7- to 8-ft section of 12-in., carbon-steel, tank farm off-gas piping. The leaking pipe was near CPP-604, approximately 50 ft away from Borehole CPP-27-1, as shown in Figure 5-46. The incident report says that some of the contamination traveled a few feet horizontally in "fingers" of sand fill that was placed beneath the piping. The longest horizontal finger was 20 ft, which was not long enough to have contaminated the CPP-27-1 borehole location. At the time of the leak, there were no transfer lines (or layers that conducted waste such as sand fill) near the CPP-27-1 location. The only waste transfer line that has ever existed near (within 20 ft) the CPP-27-1 location was a stack drain line that was installed by the 1974 PEW evaporator project and used from 1974 through 1985. That line was a 3-in. stainless-steel pipe encased in a 5-in. stainless-steel pipe. That piping configuration likely never leaked or contaminated the soil near the CPP-27-1 sample area. The nearest waste transfer line at the time of the CPP-27 leak was far from the CPP-27-1 sample location. This makes it highly unlikely that the CPP-27-1 contamination was the result of activity migration from the leak through the soil. The contamination in CPP-27-1 was more likely the result of contaminated backfill from the 1974 excavation.

The excavation area shown on Figure 5-46 was based upon July 1974 photographs taken to document the CPP-27 contamination incident. The photos were taken before the excavation to install the new PEW evaporator cell was complete (at its deepest point) and do not show the entire excavation. Based upon historical documents, the relatively small excavation area alongside CPP-604 shown in Figure 5-46 is the area containing contaminated soil found in 1974 during the investigation of the CPP-27 waste release. The actual area excavated by the 1974 PEW evaporator construction project was much larger than shown on Figure 5-46.

The 1974 PEW evaporator project excavated to an elevation approximately 24 ft below grade level to install a new CPP-604 equipment cell[a]. The new evaporator cell is shown on Figure 5-46 as the part of CPP-604 that protrudes to the east from the center section of the main building. The 1974 excavation included a haul/access road to remove soil and provide access to the construction area. The entire extent of the 1974 excavation is not certain. However, it is certain a haul road ran east from the construction site, past the north side of the stack. From there, the road may have continued east or it may have turned south around the stack. The only route for the haul road was due east from the construction area. CPP-604 blocked access from the west, the main stack blocked access from the south, and the tank farm and a WCF waste transfer line blocked access from the north. This is confirmed by 1974 photos presented as Figures 5-47, 5-48, 5-49, and 5-50.

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a. Depth of excavation is given on Drawing 155069, "CPP-604 Spare PEW Evaporatory System Plan and Sections," Rev. 5, Idaho National Engineering Laboratory, June 1994.

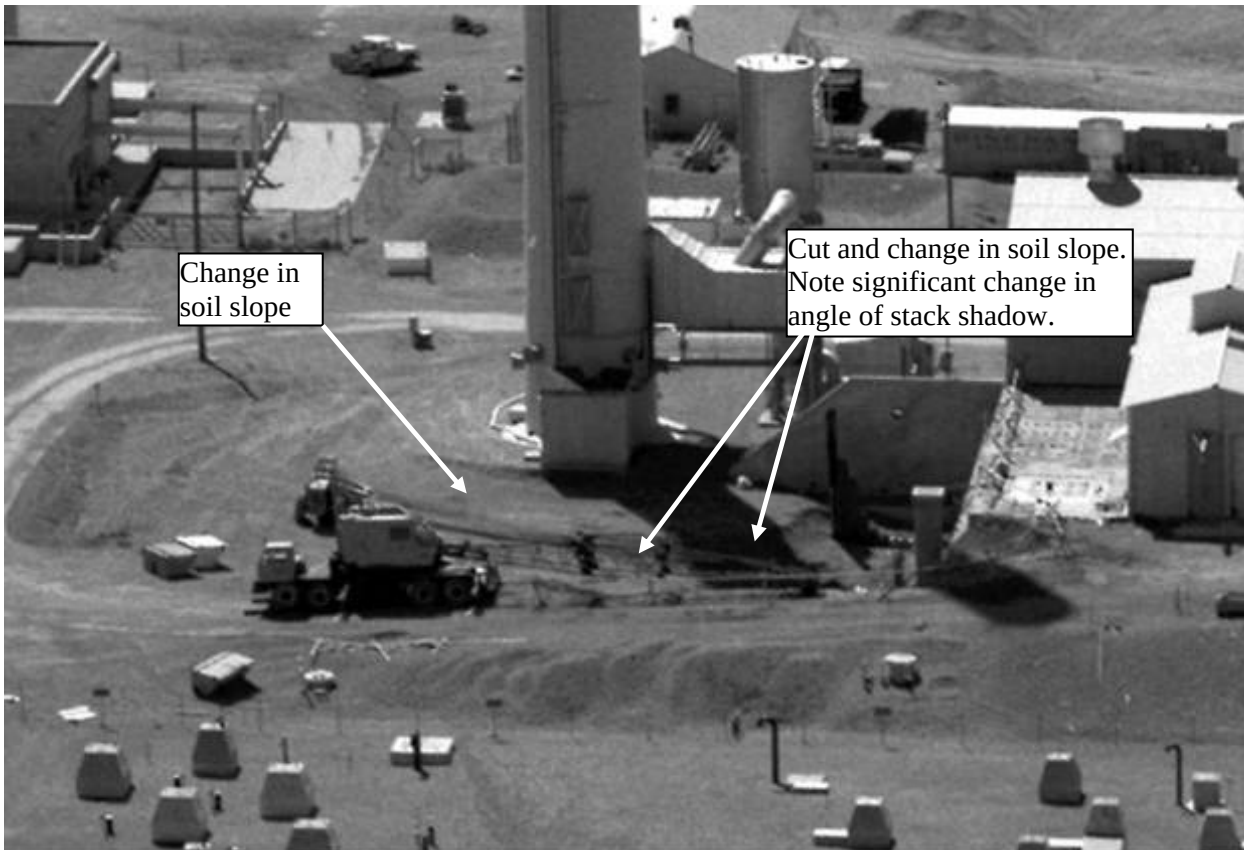


Figure 5-47. View looking south of the 1974 spare PEW evaporator construction site. Excexcavation not complete. The haul road is evident with slope changes of the soil just north of the stack (74-1094).

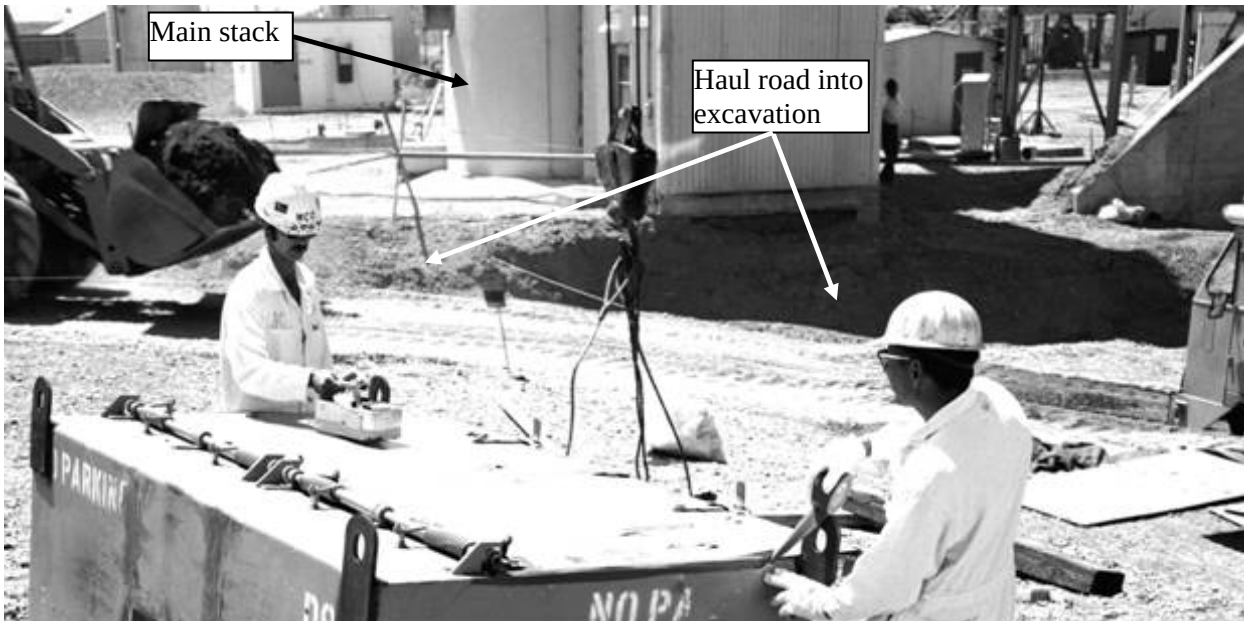


Figure 5-48. Photo showing the loading of CPP-27 contaminated soil in a box in 1974. The haul road into the excavation area is just beyond the front-end loader and runs through the stack shadow (74-2104).

Figure 5-49. View looking northwest at 1074 spare PEW evaporator cell. The access road into the excavation is visible at the bottom of the picture, directly behind the Payloader vehicle (74-2032).

Figure 5-50. View of 1974 spare PEW evaporator construction area looking south. The haul road out of the excavation is evidenced by the lack of a shadow on the far southern end of the excavation area (74-2114).

Figure 5-47 is an enlarged portion of an aerial photo (looking south) of the 1974 excavation area on the east side of CPP-604. There are two distinct lines in the soil, one just northeast of the base of the stack and a second further north that extends around the northern portion of the stack. Those lines delineate changes in the slope of the soil and show the edge of the excavation area. Figure 5-47 was taken when the excavation was about half as deep as it would eventually be for construction, so it does not show the full extent of the excavation. Figure 5-48 is a photo (looking south) of a box of contaminated soil being readied for shipment. It shows the 1974 excavation haul road running just north of the stack, through the stack shadow. Figure 5-49 is a photo (looking north) that shows the excavation for the new evaporator cell in progress. Figure 5-49 shows the steep slope of the soil around most of the construction, but it also shows the access/haul road located at the bottom of the photo, directly behind the Payloader vehicle working in the pit. Figure 5-50 is a view of the construction area (looking south) that shows a dark shadow, cast by the morning sun and the steep excavation walls, in most of the excavation area. It also shows a sunlit area on the southern end of the excavation area where the access road enters the deepest part of the excavation area. The access road was in the same location as the rectangular portion of the CPP-27 contamination site on Figure 5-46 that runs in an east/west direction just north of the main stack.

If the haul road had a 10% grade and ran east from the new evaporator cell, then the haul road elevation would have had about a 3-ft rise (to an elevation 21 ft below grade) by the time it reached the CPP-27-1 borehole location (34 ft east of the new evaporator cell). Therefore, the haul road area contains backfill to a depth of approximately 21 ft below grade at the CPP-27-2 location. Some of that backfill could have been contaminated with low (below detectable) levels of activity, or it could have had detectable activity and was deliberately used as contaminated backfill. The 2004 soil samples from CPP-27-1 contained activity to a depth of 20 ft below grade. There was no activity detected by the laboratory in any of the samples below that depth. The CPP-27-1 contaminated soil elevation correlates very well with the 1974 excavation haul road location and elevation.

The radioactivity in Borehole CPP-27-1 is likely from contaminated backfill from the 1974 spare PEW evaporator construction project, not from the direct migration of waste from the CPP-27 waste release site to the borehole location. The relatively large CPP-27 contamination site on Figure 5-46 was probably the result of contamination found in soil samples in the area north of the stack, which was probably contaminated backfill. Figure 5-46 would be more accurate if the CPP-27 contamination site and the 1974 construction areas were reversed, resulting in a relatively small contamination area next to CPP-604 and a large excavation area that contains contaminated backfill.

5.18.3 Conclusion

CPP-96, as defined in the OU 3-13 ROD, is the consolidation of the OU 3-14 contaminated soil sites (including two sites outside the tank farm boundary, which are CPP-15 and CPP-58) and the interstitial soil between the individual tank farm release sites. The interstitial soil is not associated with any specific release of waste. Instead, it contains contaminated soil that was used as backfill in historical excavation areas not included in specific contamination sites. Estimating the amount and location of the contaminated interstitial soil is not possible due to the lack of complete historical records detailing the location of contaminated backfill and estimates of contamination levels. In addition, some historical excavations likely used slightly contaminated soil as backfill that was contaminated with activity below the level of detection of the field instrumentation. Such soils would have been deemed “clean” backfill, and their location and amount are unknown.

The information presented in this report, combined with contaminated soil sample data, indicates that the use of contaminated backfill was not confined to known tank farm release sites. Backfill that was contaminated above a CERCLA level of concern could have been used anywhere in the tank farm. For these reasons, the entire tank farm surface is considered as one site (Soils Inside Tank Farm Boundary) for the purpose of assessing risk to surface receptors from contaminated soil in the tank farm. However, because the contaminated backfill originated from excavations in known release sites, it is not necessary to estimate a separate groundwater source term for interstitial soil, because the activity in interstitial soil is already included in the source terms for the individual tank farm release sites.

5.18.4 References

Allied Chemical, 1974, *ICPP Contaminated Soil Incident Findings*, draft, Document ID 23311, Alternate ID 001041, Allied Chemical Corporation, July 24, 1974.

DOE-ID, 2004, *Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/Feasibility Study Work Pla*n, DOE/ID-10676, Rev. 1, U.S. Department of Energy Idaho Operations Office, June 2004.

5.19 New Sites

New sites have been identified within waste area group (WAG) 3 since the OU 3-13 ROD was signed in 1999. Track 1s were prepared (Bragassa 2004a, 2004b) for nine shallow injection wells {SIWs). The Track 1 recommendation was “No Action Required” under CERCLA and was signed by the Agencies for these and four other SIWs. The Idaho Cleanup Project (ICP) will abandon the wells outside of CERCLA following Idaho Department of Water Resources (IDWR) requirements. These sites are summarized below and will be included in the OU 3-14 Proposed Plan and ROD to document a final decision. They will not be addressed further in OU 3-14. A nitric acid spill was discovered during trenching activities for the TFIA and this was added to Site CPP-58. The CPP-58 site boundary was expanded to include the spill. It was discussed in Section 5.14 and will not be discussed further in this section. A potential release from the concrete containment vault (CPP-784) around Tank WM-184 is new site CPP-112 and is discussed below. Other sites that are outside the tank farm, require remedial action, and are similar to OU 3-13 sites are being addressed under OU 3-13.

This subsection discusses the new information for Site CPP-112 and summarizes the 13 SIW sites, including descriptions of the release, summaries of investigations, the screening-level risk assessments performed for each of the nine sites with Track 1s, and the basis for the No Action Required agreement. These sites are shown on Figure 5-51.

The 13 SIWs within INTEC fall into two categories. Eight SIWs (CPP-102, -103, -109, -110, -113, -114, -115, -116) received steam condensate from the steam system at INTEC consisting of two boiler plants (CPP-606 and -687). Five SIWs (CPP-104, -105, -106, -107, -108) received steam condensate from lines used to heat fuel oil No. 5 in two aboveground storage tanks (VES-UTI-681 and VES-UTI-682) located near Building CPP-791, the fuel oil loading station.

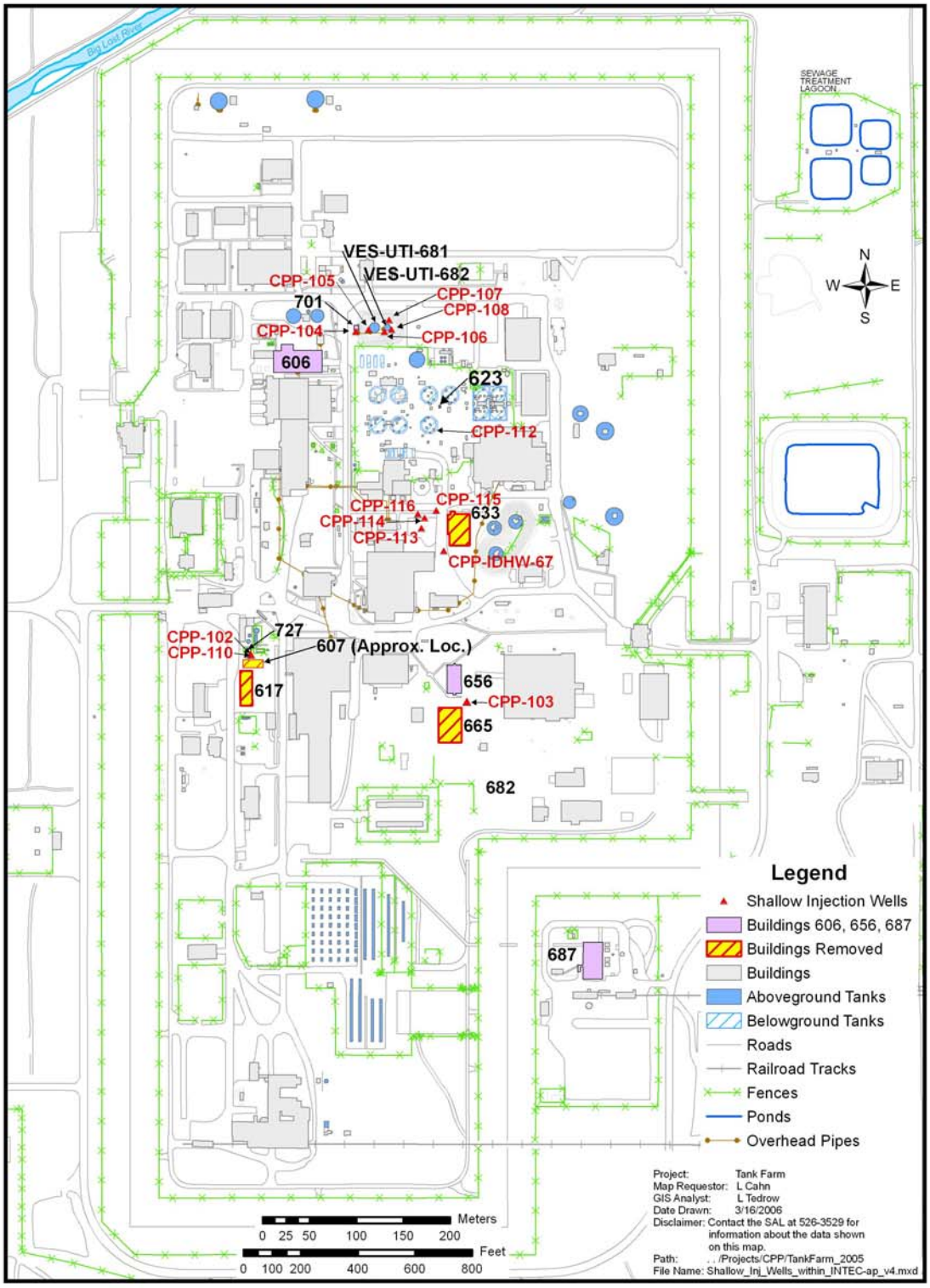


Figure 5-51. Detailed map of shallow injection wells.

5.19.1 Shallow Injection Wells from INTEC Steam System

The INTEC steam system consisted of two boiler plants (CPP-606 and -687), which supplied steam to various buildings and installations throughout INTEC. CPP-606, the service building powerhouse, is still in service; whereas CPP-687, the coal-fired boiler house, was in operation from 1984 until 1999. Information associated with buildings and systems that discharged to the individual wells is given below. For identification purposes, they are identified by the CERCLA site number, followed by the record number - facility number, the IDWR record number, then the well name in parentheses.

5.19.1.1 CPP-102; 4-CPP; #54; (CPP-621-4). This SIW is north of Building CPP-617 and south of the Fluorinel Dissolution Process and Fuel Storage (FAST) hydrofluoric acid tank (CPP-727). This well received condensate from Building CPP-607's heating system and was believed to have received condensate from a steam line used to steam-trace the hydrofluoric acid tank. Steam-heated tracing systems were used to keep chemicals flowing freely in all weather. The SIW is a precast concrete manhole with a 6-in., drain hole cored through the manhole bottom. It is no longer in use and there are no plans for future use. All piping leading to the SIW from CPP-607 and CPP-727 was removed and it has been fitted with a manhole cover (MAH-CS-LS-091).

5.19.1.2 CPP-103; No Record Number-Facility Number; No IDWR Record Number; (MAH-CA-CT-319). This SIW was located south of Building CPP-656 and north of Building CPP-665. It served Building CPP-665, which was a 19,200-ft^2 office building. The SIW received steam condensate from the heating and ventilation equipment located inside CPP-665 and was placed in inactive status during 2001. During the construction project to deactivate Building CPP-665, the SIW was removed, the condensate line partially removed and capped, and the area backfilled with gravel. Building CPP-665 was demolished on June 7, 2004.

5.19.1.3 CPP-109; 27-ICPP; #67; (CPP-IDHW-67). This SIW is southwest of the WCF, CPP-633. It received steam condensate from CPP-633's heating and ventilation system. Building CPP-633, a 17,250-ft^2 facility, was decommissioned and a closure cap was installed over the building footprint. This SIW was taken out of service and the condensate line leading from the building to the well was disconnected and grouted during the decommissioning and RCRA closure of CPP-633 in 1998.

5.19.1.4 CPP-110; 33-ICPP; No IDWR Number; (CPP-607S). This SIW was located north of Building CPP-617 and south of Building CPP-607. This well received steam condensate from CPP-607's heating and ventilation system. CPP-607, a 2,560-ft^2 storage building, was decommissioned and dismantled in 1999-2000. The SIW and piping were removed during the decommissioning process and the area was filled with dirt.

5.19.1.5 CPP-113; 39-CPP; No IDWR Number; (MAH-WDS-HS-051). This SIW is located inside the earthen berm between VES-WDS-100 and VES-WDS-101, south of the CPP-702 building. Three separate steam condensate lines discharge to CPP-113. One discharge was from supply lines from CPP-702, and the other two were steam condensate lines from the heating coils associated with the two tanks. The well measures 3 ft, 9 in. × 4 ft square and is approximately 12 ft, 6 in. below grade.

5.19.1.6 CPP-114; 40-CPP; No IDWR Number; (No Well Name). This SIW is located east of the Fuel Oil Unloading Shelter, CPP-702. From 1952 to 1994, this well received a steam condensate discharge from two radiators used to heat the 216-ft^2 CPP-702 shelter. The well is approximately 3 ft in diameter, filled with rocks and gravel; the bottom is approximately 6 ft below grade. There is no surface opening for the well, as the area is covered with asphalt.

5.19.1.7 CPP-115; 45-CPP; No IDWR Number; (CT-NN-156770). This SIW is located in the Olive Avenue tunnel south of CPP-659. The well was activated in approximately 1981 and was inactivated with the reroute of the drip leg to the condensate return system in December 2004. It is a condensate drip leg that discharged to a 3/4-in. pipe perforated with 1/8-in. holes, and 1/2-in. on center in medium rock and 1 ft all around. The bottom of the well is located approximately 12 ft below existing grade.

5.19.1.8 CPP-116; 46-CPP; No IDWR Number; (CT-NN-156757). This SIW is located in the Olive Avenue tunnel northwest of CPP-633. The well was activated in approximately 1981 and was inactivated with the reroute of the drip leg to the condensate return system in December 2004. It is a condensate drip leg that discharged to a 3/4-in. pipe perforated with 1/8-in. holes, and 1/2-in. on center in medium rock and 1 ft all around. The bottom of the well is located approximately 8 ft below existing grade.

5.19.1.9 Basis for No Action Required. The hazardous substances discharged to the SIWs were identified based on process knowledge. Operators were interviewed who had run the system and were familiar with previous operations data. Actual data records are not available for the early years of operation for the boiler system. The concentration for the hazardous constituent, cyclohexylamine, was conservatively estimated using process knowledge. Its estimated concentration did not exceed the EPA Region 9 risk-based concentration (RBC) for screening soil. Therefore, the recommendation was that no action would be required under CERCLA.

The SIWs identified most recently (CPP-113, -114, -115, -116) are bounded by the Track 1 assessments on the other nine SIWs. This is based on the similar operations (received steam condensate from building or petroleum tank heating); volume of condensate due to building area, tank volume, or system heated: timeframe of operation (1950 – 1985); and extent/years of operation. Therefore, post-1985 operations are bounded by the calculations performed for pre-1985 operations. Less toxic chemicals were used and better operating practices were implemented (i.e., less chemical use).

The Agencies agreed to the determination that no action was required for the four SIWs under CERCLA due to the low risk from these sites. These SIWs will be closed outside of the CERCLA program in accordance with IDWR requirements. These sites will not be considered further in the OU 3-14 RI/BRA and will be addressed in the OU 3-14 Proposed Plan and ROD.

5.19.2 Shallow Injection Wells Associated with Fuel Oil Storage Tanks

These SIWs ensured the proper viscosity for transferring fuel oil and also for operating the boiler system in Building CPP-606, the service building powerhouse. The two fuel oil tanks associated with these SIWs are VES-UTI-681 (244,000 gal) and VES-UTI-682 (50,000 gal) and are located near Building CPP-701, the fuel oil loading station. These two storage tanks reside inside a 15-ft gravel berm. VES-UTI-681 was put into service in 1951, while VES-UTI-682 was put into service in 1960. The fuel oil tanks are still in service today and store a fuel oil type that does not require heating.

Four of the SlWs reside within the berm and in close proximity to the two storage tanks. The other SIW (CPP-104) is located south of Building CPP-701 and outside the berm. These SIWs were taken out of service in 1986 due to failure of steam lines and consequent solidification of the fuel oil. During the removal of the solidified fuel, some of the fuel oil was spilled on the ground around the cleanout portal of Tank VES-UTI-682. The stained, gravelly soils had an appearance similar to asphalt. The stained soils were removed from inside the berm in 1986-1987, 1997, and 2002. In 1986, the subcontractor removed the visibly contaminated soil around the storage tank. In 1997, it was discovered that not all of the contamination had been cleaned up and additional soil was removed. In 2002, the

contaminated area was excavated to a depth of about 2 ft, after sampling results demonstrated that the concentrations of COCs exceeded the State of Idaho's Risk-Based Corrective Action (RBCA) for Petroleum Releases Tier 0 cleanup levels. A Tier 2 analysis was conducted under RBCA for the fuel oil storage release site, excluding the SIWs. The Tier 2 modeling results demonstrate that the calculated risk does not exceed the RBCA Tier 2 action levels; thus, no action was recommended and the report was submitted to DEQ in November 2003.

5.19.2.1 CPP-104; 19-CPP; #75; (CPP-701, CPP-701 SI-AT-SB and MAH-FOS-FL-314).

This SIW resides outside the berm and south of Building CPP-701. The SIW is equipped with a metal lid and hinged door. A condensate line, two fuel oil transfer lines, and a high-pressure steam line ran through this SIW and back towards CPP-606. The condensate line exiting this SIW connected into the service waste line coming from Building CPP-644 near Building CPP-606.

5.19.2.2 CPP-105; 20-CPP; #76; (CPP-701 -A, CPP-701 -A SI-AT-SB and DVB-FOS-HS-F5).

This SIW resides within the berm and is associated with the 244,000-gal fuel oil tank, VES-UTI-681. It is located on the west side of the fuel tank. This SIW is constructed of concrete and is equipped with a metal lid. The condensate line from the oil tank heater (HE-UTI-622) dispelled condensate into this SIW and connected back into the main condensate line traveling back towards CPP-606.

5.19.2.3 CPP-106; 21-CPP; #77; (CPP-701-B-1, CPP-701-B FD-AT-SB).

This SIW resides within the berm and is associated with the 50,000-gal fuel oil tank, VES-UTI-682. It is located on the southwest side of the fuel tank. This SIW is constructed of galvanized metal with a metal lid. The condensate line from the oil tank heater (HE-UTI-623) dispelled condensate into this SIW and connected back into the main condensate line traveling back towards CPP-606.

5.19.2.4 CPP-107; 22-CPP; #78; (CPP-701-B-2, CPP-701-B SI-AT-SB).

This SIW resides within the berm and is associated with the 50,000-gal fuel oil tank, VES-UTI-682. It is located on the northern side of the fuel tank. This SIW is constructed of galvanized metal and has a metal lid. The condensate line from the oil tank heater (HE-UTI-624) dispelled condensate into this well and connected back into the main condensate line traveling back towards CPP-606.

In late 1986, the steam lines failed, causing the solidification of fuel oil No. 5 within the VES-UTI-682 tank. A subcontractor removed the solidified fuel from the storage tank and, subsequently, spilled some of the fuel oil on the ground around the cleanout portal and near this SIW. The contaminated soil surrounding this SIW and in the general area of the storage tank was excavated, but noticeable residual fuel oil is visible inside this SIW.

5.19.2.5 CPP-108; 23-CPP; #79; (CPP-701-B-3, CPP-701-B FD-AT-SB Dry Well).

This SIW resides within the berm and is associated with the 50,000-gal fuel oil tank, VES-UTI-682. It is located on the eastern side of the fuel tank. This SIW is constructed of galvanized metal with a metal lid. The condensate line from the oil tank heater (HE-UTI-625) dispelled condensate into this SIW and connected back into the main condensate line traveling back towards CPP-606. Visual inspection indicated slight soil discoloration; but no releases, other than steam condensate, are documented.

5.19.2.6 Basis for No Action Required.

The hazardous substances discharged to the SIWs were identified based on process knowledge. Operators were interviewed who ran the system and were familiar with previous operations data. Actual data records were not available for the early years of operation for the boiler system.

The concentration for the hazardous constituent, cyclohexylamine, which is associated with the steam condensate, was conservatively estimated using process knowledge, and it did not exceed the 10^{-6} RBC from the EPA Region 9 Preliminary Remediation Goals (PRGs) for screening soil sites.

The fuel oil contaminant concentrations were based on sample results, and the majority of the constituents were below the 10^{-6} RBC from the EPA Region 9 PRGs for screening soil sites. Three constituents exceeded the 10^{-6} RBC but did not exceed the 10^{-4} RBC, which is consistent with the remediation goals provided in the OU 3-13 Final ROD for the INTEC (DOE-ID 1999). Under OU 13-13, these sites would become No Action sites.

Based on the evaluation presented in the Track 1 Decision Documentation Package, these five SIWs do not pose an unacceptable risk to human health and the environment and the Agencies agreed to "No Action Required" under CERCLA. Because no action is required under CERCLA to protect human health and the environment, these SIWs will be closed under other regulatory programs. Abandonment of these SIWs will be in accordance with IDWR requirements.

5.19.3 Site CPP-112

New site CPP-112 is a potential release from the tank farm concrete containment vault (CPP-784) around Tank WM-184. On November 18, 2003, approximately 2,000 gal of deionized (DI) water were used to rinse down the interior sides of the concrete vault containing stainless-steel tank WM-184. This DI water/rinsate was then pumped into Tank WM-184. The quantity of water was measured as it was being used and was run through a flow meter when transferred into the tank. There was an apparent discrepancy between these two measurements of about 1,000 gal. The flow measurement devices were recalibrated to determine if they might have been the cause of the discrepancy between the two water measurements. Because these devices were designed for much larger volumes, it was determined that the flow devices could not accurately measure low volumes (e.g., 2,000 gal or less). Therefore, it was not possible to conclusively determine whether 1,000 gal were missing. On December 7, 2003, duplicate samples of the DI water/rinsate were taken from the vault sumps for analysis and, on December 15, 2003, the DEQ was notified that there might have been a release to the environment.

More information on the tank/vault configuration and analytical results of the vault water appear in the new site identification information form for CPP-112 (CPP-112 2005). Although a release to the environment was not likely, a conservative source term for CPP-112 was developed based on assuming that 1,000 gal leaked and that the water contained the maximum concentration of the sample or the duplicate. The source term for the groundwater COPCs for which there were analytical data is shown in Table 5-48. Because this conservatively estimated source term for the CPP-112 leak is between 5 and 11 orders of magnitude less than the total OU 3-14 source term, the inclusion of the CPP-112 source term in the INTEC model would not affect the model outcome.

Table 5-48. Conservative source term for CPP-112, assuming 1,000 gal leaked.

COC	H-3 (Ci)	Sr-90 (Ci)	NO_3 (kg)
Activity or mass	1.04E-05	4.01E-06	4.13E-02

5.19.4 References

Bragassa, J. L., 2004a, "Track 1 Decision Documentation Package - No Action Required - Investigation for Shallow Injection Wells CPP-104, CPP-105, CPP-106, CPP-107 and CPP-108 Associated with Fuel Oil Storage Tanks (CPP-701), Operable Unit 3-13, Waste Area Group 3," Document ID 24863, Bechtel BWXT Idaho, April 27, 2004.

Bragassa, J. L., 2004b, "Decision Documentation Package - Track 1 Sites CPP-102, CPP-103, CPP-109 and CPP-110 - Shallow Injection Wells Located at INTEC, Operable Unit 3-13, Waste Area Group 3," Document ID 24884, Bechtel BWXT Idaho, March 23, 2004.

CPP-112, 2005, "WM-184 CPP Tank Farm Containment Vault Potential Release," Document ID 24908, Idaho Cleanup Project, Idaho National Laboratory, June 9, 2005.

DOE-ID, 1999, *Final Record of Decision, Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho*, DOE/ID-10660, Rev. 0, U.S. Environmental Protection Agency, Idaho Department of Environmental Quality, U.S. Department of Energy Idaho Operations Office, October 1999.

5.20 Suspect Piping

Due to the high numbers of piping runs and different designs used to transfer waste within the Tank Farm Facility, piping integrity is potentially an important consideration in the RI process. Some piping/encasement designs proved to be very reliable over the years of operation; others did not. Generally, the stainless-steel pipe-in-a-pipe design has been trouble-free, with both the inner and outer material being compatible with the acidic wastes. The stainless-steel-lined concrete-trough system has also experienced few problems. The split tile- and split steel-encased lines, on the other hand, had secondary containment problems due to incompatibility with the acidic waste and/or structural stability. Additionally, carbon-steel lines installed in the tank farm had the potential to come into contact with waste via valves that were improperly set, which could cause corrosion.

Based on the release mechanisms of the known release sites, it can be generally concluded that the larger releases were a result of using carbon-steel piping at inappropriate locations, containment failure of split tile or split steel encasements, or valve leaks associated with the split tile or split steel encasements. The use of split tile encasement was limited to waste transfer lines associated with the construction of Tanks WM-180 and -181. Therefore, the area between the CPP-604 tank vault and WM-180 and -181 was generally the only area within the tank farm to use the split tile encasement. Because this area has been excavated extensively during tank farm improvement projects, any significant releases associated with the piping would have most likely been discovered. Tanks WM-180 and -181 both have short sections of split tile-encased stainless-steel lines on the north side of the tanks. These lines were originally stubbed out of the tank and capped for future use. Two lines, one on each tank, were subsequently connected to the waste transfer system and used to handle waste. Strict administrative controls were placed on these lines to minimize their use, reducing the risk of release. A more detailed description of these administrative controls can be found in Section 2.4.4.1 of the OU 3-14 RI/FS Work Plan (DOE-ID 2004). Because a short section of split tile encasement has been used, the piping was considered suspect. However, no known leaks or unusual occurrences are associated with the use of these two lines, and releases were unlikely.

The split steel encasement also had limited use in the same area between the CPP-604 tank vault and WM-180 and -181. Approximately 160 ft of the piping/encasement were used and has since been abandoned or removed. The excavation activity in the area where the piping was used would have uncovered any leaks in addition to the one discovered at CPP-28.

The largest contaminant release within the tank farm has been the release at CPP-31, where a carbon-steel drain line came into contact with acidic waste solution. The intended use of the line was a drain line for cooling water in the event cooling water became contaminated. An incorrectly positioned valve allowed waste solution to back into the carbon-steel drain line, causing corrosion and failure of the line. Because of this piping configuration, tank farm personnel checked all of the piping flow sheets in 1975 for the entire tank farm to determine whether other previously unsuspected leak mechanisms exist. Particular attention was paid to interfaces with encased waste transfer lines. One connection of a carbon-steel line to a transfer line from WM-181 to the dilute waste evaporator feed tank was discovered. This line was disconnected, and a blind was installed on the stainless-steel line (Allied Chemical 1975).

In summary, waste transfer piping having the inferior encasement designs serviced only small portions of the tank farm. Only a few carbon-steel lines were identified that had the potential to come into contact with corrosive liquid wastes, but these were located in areas that have already been excavated. Those short sections of piping still employing the split tile encasement have had strict administrative controls limiting their use.

5.20.1 References

Allied Chemical, 1975, *Investigation Report for the ICPP Contaminated Soil Incident*, Document ID 27156, Alternate ID 003798, Allied Chemical Corporation, September 18, 1975.

DOE-ID, 2004, *Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/Feasibility Study Work Plan*, DOE/ID-10676, Rev. 1, U. S. Department of Energy Idaho Operations Office, June 2004.

6. INTRODUCTION TO RISK ASSESSMENT AND CONCEPTUAL SITE MODEL

The purpose of this baseline risk assessment (BRA) is to evaluate adverse impacts on human health and the environment from historical releases at the INTEC tank farm. This section provides an introduction to the conceptual site model (CSM) for the risk assessment and summarizes the risk assessment exposure scenarios and analytical processes.

6.1 Conceptual Site Model

A CSM has been developed for the Operable Unit (OU) 3-14 remedial investigation/baseline risk assessment (RI/BRA) to identify the primary contaminant sources and release mechanisms, secondary sources and release mechanisms, exposure pathways, exposure routes, and classes of receptors specific to this risk assessment. Figure 6-1 is an artist's conception illustrating the primary mechanisms for contaminants to migrate from the source to the receptors. Figure 6-2 presents the detailed CSM. Two primary sources exist—the tank farm system and the former injection well. Leaks and spills from the tank farm piping and valves resulted in secondary contaminated soil sources. Human exposures to these contaminants can occur by direct contact with surface soils at the spill sites, or the contaminants can be transported via suspension (wind erosion), plant uptake, or infiltration of water and subsequent leaching. Potential human exposure routes include gamma-emitting radionuclides in the soil (direct exposure), incidental ingestion of soil, dermal contact (absorption through the skin), inhalation, and ingestion of contaminated groundwater. Along with contaminated soils, the former injection well contributes to the groundwater exposure pathway and the groundwater ingestion exposure route.

All of the soil sites evaluated in this risk assessment lie inside of an industrial use zone (Figure 4-3) both for current and future use. Therefore, only occupational worker exposure scenarios (both current time period and in the future [2095]) are evaluated in the soil risk assessment in Section 7. A potentially complete (PC) exposure pathway/route means that the source, release mechanism, pathway, exposure route, and receptor presence are possible. An incomplete (I) exposure pathway indicates that one or more of these criteria (e.g., source, exposure route, or receptor) do not exist and that there is no potential risk to a receptor from site-related contaminants. A hypothetical future resident living outside the industrial use area could be exposed to contaminated groundwater; therefore, this pathway is assessed in Section 8.

6.2 Surface Soil

The risk assessment for surface soils is performed in three processes—exposure assessment, toxicity assessment, and risk characterization—to estimate the incidental cancer risk and noncancer health effects on humans from potential exposure to site-related contaminants. The exposure assessment process for surface soils (Section 7.2.1) determines the potential exposure routes, magnitude, frequency, and duration of receptor exposure to contaminants and estimates total dose (intake or external exposure) for each class of receptor. The OU 3-13 RI/BRA (DOE-ID 1997) demonstrated that the primary exposure route for surface soil contaminants at the tank farm is direct exposure route from gamma-emitting radionuclides and that other exposure routes (soil ingestion, inhalation, ingestion of produce) made an insignificant contribution to total risk (Section 7.1), especially for the worker exposure scenario. Therefore, these pathways were not reevaluated in the OU 3-14 RI/BRA.

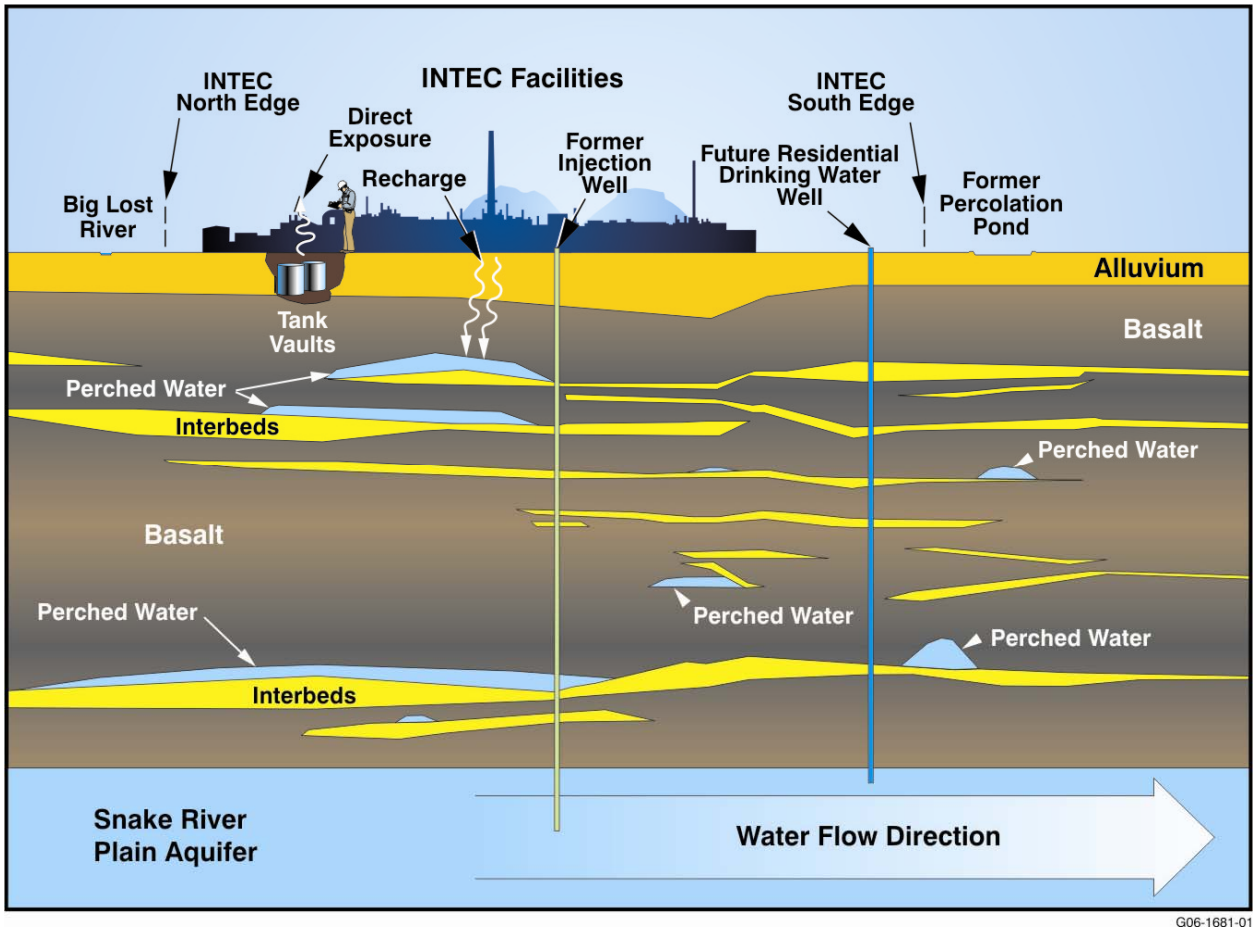
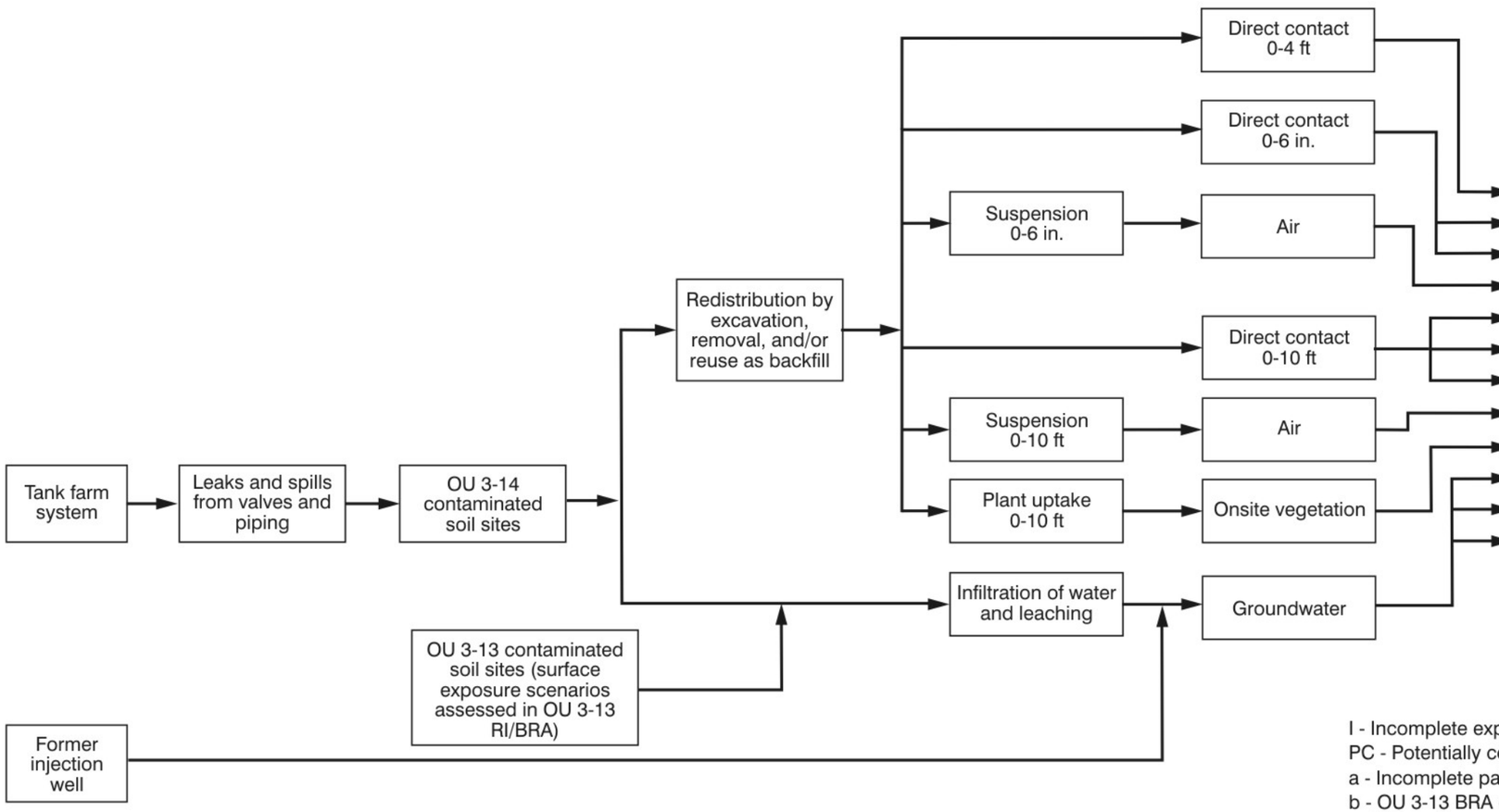


Figure 6-1. Artist's conception of the conceptual site model.



Exposure route	Receptors			
	Future residents	Current workers	Future workers	Ecological
Direct exposure	NA	● I[a]	● PC	NA
Soil ingestion	NA	I[b]	PC[b]	NA
Dermal contact	NA	I[b]	PC[b]	NA
Inhalation	NA	I[b]	PC[b]	NA
Direct exposure	I[c]	NA	NA	● PC
Soil ingestion	I[b]	NA	NA	● PC
Dermal contact	I[b]	NA	NA	NA
Inhalation	I[b]	NA	NA	NA
ingestion	I[b]	NA	NA	● PC
Ingestion	● PC	NA	NA[d]	I
Inhalation	PC[b]	NA	NA[d]	I
Dermal contact	PC[b]	NA	NA[d]	I

I - Incomplete exposure route.
PC - Potentially complete exposure route.
a - Incomplete pathway due to administrative controls but reevaluated in OU 3-14 BRA.
b - OU 3-13 BRA concluded exposure route was insignificant contributor to risk. Will not be re-evaluated in OU 3-14 BRA.
c - Incomplete pathway in industrial use area
d - Not assessed because residential exposure scenario is more conservative.
NA - Not assessed.
● - Exposure route evaluated in OU 3-14 BRA.

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Figure 6-2. OU 3-14 conceptual site model showing groundwater source term, OU 3-14 and OU 3-13 contributing sources.

The toxicity assessment (Section 7.2.2) identifies contaminant-specific toxicity criteria (e.g., EPA carcinogenic slope factors [SFs]) that can be used to evaluate health impacts for a given dose. Risk characterization (Section 7.2.3) combines the results of the exposure and toxicity assessments to quantify the excess cancer risk due to exposure to surface soil contaminants at the tank farm.

6.3 Groundwater

The groundwater pathway evaluation is presented in detail in Appendix A and summarized in Section 8. A vadose zone and groundwater model was developed for INTEC and incorporates subsurface transport of historical releases to the environment. It includes the former injection well, leaks from tank farm valves and piping, and infiltration of water and leaching from all contaminated OU 3-13 and OU 3-14 soil sites. The model is used to predict maximum contaminant concentrations in the Snake River Plain Aquifer (SRPA) that will occur in the future. These peak future concentrations are then used to estimate the human health risk and hazards associated with potential groundwater consumption by future residential receptors outside the tank farm.

6.4 Ecological

The risk to ecological receptors was evaluated in a screening approach. Maximum concentrations were compared to ecologically based screening levels or ecological soil screening levels. Contaminants that exceed these ecologically based screening levels or ecological soil screening levels were then used to calculate an exposure using a simplified food web. The modeled dose was divided by the toxicity reference value (TRV) to produce a hazard quotient for each contaminant and receptor of concern (see Sections 7.4 to 7.6 for a discussion of the ecological risk assessment screening approach and results). Contaminated soil represents the major source of exposure for OU 3-14 ecological components. For the ecological screening and evaluation, soils are defined at depths of 15 cm to 3 m (0.5 to 10 ft). Contaminants in subsurface soil can be transported to ecological receptors by plant uptake and translocation by burrowing animals. Exposure was evaluated for ingestion of soil and through the food web by evaluating ingestion of plants and prey. Internal and external exposure to radionuclides was also assessed. Dermal and inhalation are considered difficult to assess and an insignificant exposure route and were not evaluated. Contamination depths greater than 3 m (10 ft) below surface are considered inaccessible to ecological receptors, because this is generally below the root zone of plants and burrowing depth of ground-dwelling animals. Groundwater is not evaluated for ecological receptors because there is no access to groundwater at the INL Site except through human activities.

6.5 References

DOE-ID, 1997, *Comprehensive RI/FS for the Idaho Chemical Processing Plant OU 3-13 at the INEEL—Part A, RI/BRA Report (Final)*, DOE/ID-10534, U.S. Department of Energy Idaho Operations Office, November 1997.

7. SOIL RISK ASSESSMENT

The purpose of this portion of the assessment is to perform a human health risk assessment (HHRA) and an ecological risk assessment (ERA) to evaluate adverse impacts on human health and ecological receptors resulting from exposure to site-related contamination in the surface soil within OU 3-14. This section describes the methodology for conducting the Operable Unit (OU) 3-14 surface soil HHRA and ERA.

The goals of the HHRA and the ERA are to

- Analyze the receptor risks from surface exposure to soil contaminants to help determine the need for action both at a tank-farm-wide level and at specific release sites
- Provide a basis for comparing potential health impacts of various remedial alternatives
- Document the analysis in a form that is useful for making risk management decisions.

Section 7.1 summarizes the results of the HHRA in the OU 3-13 Remedial Investigation/Baseline Risk Assessment (RI/BRA) (DOE-ID 1997a) and its impact on the OU 3-14 HHRA. Section 7.2 describes the HHRA methods, including the exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. Section 7.3 gives the results of the HHRA. Sections 7.4 to 7.6 present the approach and results of the ERA.

7.1 Summary of OU 3-13 Soil Risk Assessment and Impacts on OU 3-14

7.1.1 OU 3-13 Soil Risk Assessment

A risk assessment for all OU 3-14 sites was previously performed in the OU 3-13 BRA. Because the OU 3-14 is only a focused BRA and relies heavily on the results of the OU 3-13 BRA, the results of the OU 3-13 BRA are summarized below.

Sites were grouped for soil risk calculations in the OU 3-13 BRA into two groups, the Tank Farm Group and the Tank Farm South Group, as shown on Figure 7-1. The Tank Farm Group consisted of Sites CPP-20, CPP-25, CPP-26, CPP-28/79, CPP-31, and CPP-32 (included CPP-32E and CPP-32W). Sites CPP-28 and CPP-79 were considered together, because the source of contamination for these two sites was thought to be the same. Site CPP-79 was not divided into a shallow and deep site until the OU 3-14 analysis identified two different releases.

The Tank Farm South Group consisted of CPP-15, CPP-27/33, and CPP-58. Sites CPP-27 and CPP-33 were derived from the same transfer line leak and were considered together in the OU 3-13 RI/BRA and all Track 2 investigations.

Three tank farm soil contamination sites were evaluated and eliminated as no action sites in the OU 3-13 process: CPP-16, CPP-24, and CPP-30 (DOE-ID 1999a). No new information exists for these sites, but the OU 3-13 Record of Decision (ROD) specified that these sites would be evaluated as part of the OU 3-14 assessment.

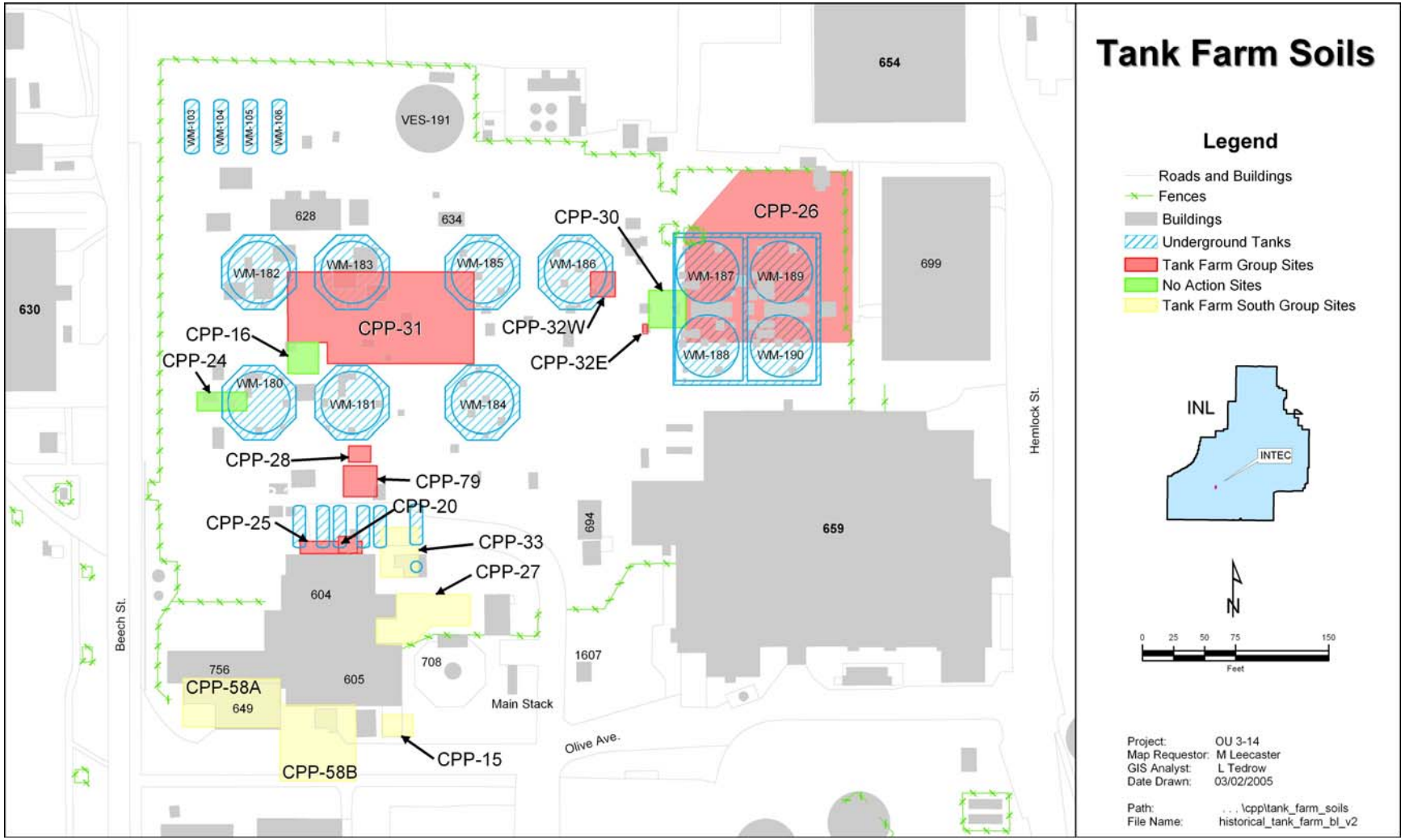

Figure 7-1. Map of OU 3-13 RI/BRA grouping (Tank Farm Group, Tank Farm South Group, and no action sites). Note that the Site CPP-58 boundary was smaller in OU 3-13 because it predated the discovery of new sites that are included in OU 3-14.

A summary of the surface pathway risk results determined for the tank farm soil sites is given in Table 7-1 (Note that hazard indices [HIs] are not presented here because all OU 3-13 HIs were either 0 or far less than 1). These results are taken from Chapters 10 and 11 of the OU 3-13 RI/BRA (DOE-ID 1997a). If the calculated risk is greater than 1×10^{-4} or the HI is greater than 1, then adverse health effects are possible and remedial action is normally employed to reduce risk at a site. The OU 3-13 results indicate that adverse health effects could occur from exposure to Cs-137 in tank farm soil. For the Tank Farm Group sites, all the calculated risk was due to external exposure from Cs-137, with insignificant contributions from external exposure to Eu-154 and U-235, including progeny. For the Tank Farm South Group sites, all the risk was also due to external exposure from Cs-137, with an insignificant contribution from Sr-90 via the ingestion pathway. The risk results for the other pathways (besides direct exposure) evaluated in the OU 3-13 BRA are summarized below:

- Inhalation of volatile organic compounds (VOCs) – This exposure route is based on contaminant concentrations in the top 0 to 6 in. of soil for workers and 0 to 10 ft for residents. The maximum predicted risk from inhalation of volatiles was 1E-17 (see Table 7-5 in the OU 3-13 ROD and Table 27-5 in the OU 3-13 RI/BRA), and the maximum predicted HI was 0 (see Table 7-6 in the OU 3-13 ROD and Table 27-6 in the OU 3-13 RI/BRA). The risk and HI from inhalation of VOCs are well below the risk threshold of 1×10^{-4} or the HI criteria of 1 and are extremely small relative to impacts from the external exposure route.

- Inhalation of fugitive dust (particulates) – This exposure route is based on contaminant concentrations in the top 0 to 6 in. of soil for workers and 0 to 10 ft for residents. Maximum predicted risk was 3E-14 (see Table 7-5 in the OU 3-13 ROD and Table 27-5 in the OU 3-13 RI/BRA), and maximum predicted HI was 4E-6 (see Table 7-6 in the OU 3-13 ROD and Table 27-6 in the OU 3-13 RI/BRA). The risk and HI for the inhalation of airborne particulates are well below the risk threshold of 1×10^{-4} or the HI criteria of 1 and are extremely small relative to impacts from the external exposure route.

Table 7-1. Summary of the surface pathway OU 3-13 RI/BRA risk results for the Group 1 soil sites (hazard quotients and indices were 0 or far below 1 and are not presented).

			Exposure Scenario Excess Risk of Incurring Cancer		
Group	Contaminant of Concern	Half-life (years)	Current Worker	Future Worker (in 2095)	Future Resident (in 2095)
Tank Farm	Cs-137	30	5E-01	5E-02	3E-01
	Eu-154	8.6	1E-3	4E-7	6E-6
	U-235	10^9	6E-4	6E-4	3E-3
	Co-60	5.3	1E-4	2E-10	2E-9
	Total	N/A	5E-01	5E-02	3E-01
Tank Farm South	Cs-137	30	1E-02	1E-3	6E-3
	Sr-90	29	2E-8	2E-9	6E-7
	Arsenic	N/A	---[a]	---[a]	1E-5
	Total	N/A	1E-02	1E-3	6E-3

a. "---" indicates the contaminant is not a contaminant of potential concern (COPC) in the medium or at the site.
N/A = not applicable.

- Incidental ingestion of surface soil – This exposure route is based on contaminant concentrations in the top 0 to 6 in. of soil for workers and 0 to 10 ft for residents. For all the OU 3-13 tank farm sites, the maximum risk to the current and future onsite worker from incidental ingestion of surface soil was 7E-8 (OU 3-13 RI/BRA, Tables 10-12, 10-14, 11-10, and 11-12). For all the OU 3-13 tank farm sites, the maximum hazard quotient for the current and future onsite worker from the ingestion of surface soil was zero (OU 3-13 RI/BRA, Tables 10-13, 10-15, 11-11, and 11-13). The risk and hazard quotients for the ingestion of surface soil are well below the risk threshold of 1×10^{-4} or the hazard quotient of 1 and are extremely small (0.0002% of the total) relative to impacts from the external exposure pathway.

- Dermal absorption from soil – This exposure route is based on contaminant concentrations in the top 0 to 6 in. of soil for workers and 0 to 10 ft for residents. A qualitative evaluation of dermal absorption was made in the OU 3-13 BRA (DOE-ID 1997a, Section 7.1.3.1). This route was eliminated from consideration because (1) dermal absorption from soil exposure will produce smaller calculated risks than the soil ingestion exposure route for all Waste Area Group (WAG) 3 COPCs; (2) absorption factors for most WAG 3 COPCs are not well defined; and (3) organic contaminants, the class most likely to contribute to risk via this route, are not widespread at WAG 3.

Since completion of the OU 3-13 RI/BRA, the radionuclide slope factors (SFs) used to calculate the above risks were increased by EPA (Health Effects Assessment Summary Tables [HEAST]—Radionuclides Table [EPA 2006a]), which would increase the above-calculated risks for individual radionuclides. For the inhalation and ingestion (food and soil) pathways, the SF increases (maximum factor increase of 3.5) would not impact the final calculated total risk because of the overwhelming influence of the direct external radiation pathway in the total risk. They would, however, slightly increase (by a factor of 1.2) the direct radiation risk from Cs-137—from 5E-01 to 6E-01 for the Tank Farm Group and from 6E-03 to 7E-03 for the Tank Farm South Group. In addition, a new external radiation cancer SF is now available for Sr-90, which would provide an insignificant increase in the total calculated risk from this pathway. For the OU 3-14 risk assessment, these new radionuclide SFs were used (see Section 7.2.2).

7.1.2 Use of OU 3-13 Results in Focused OU 3-14 BRA

Because of data gaps concerning the nature and extent of contamination at tank farm soil sites in the OU 3-13 RI/BRA (DOE-ID 1997a), a final decision on this unit was deferred until additional sampling could be performed. New soil sampling was performed in 2004 for five sites, and the OU 3-14 soil BRA reevaluates surface exposure risks based on both the previous OU 3-13 data and new sampling data. The basic approach is to use the results of the OU 3-13 BRA when no new sampling information is available and to use the methodology developed for the OU 3-13 BRA to incorporate new sampling data.

The scope of the OU 3-14 risk assessment is reduced from that performed for the OU 3-13 BRA because much of the risk assessment related to tank farm soil was completed in the OU 3-13 analysis. Specifically, the OU 3-13 BRA established that significant risk to current and future workers from exposure to contaminants in the surface soil may occur and that this risk was due to the direct gamma radiation exposure pathway, which is calculated for worker scenarios based on contaminant concentrations in the upper 0 to 4 ft of soil. All CERCLA risk assessments at the INL Site use a maximum depth of 4 ft for surface pathways based on an assumption that workers might dig below the frost line for building foundations. Although residential scenarios were calculated for the OU 3-13 BRA, the Agencies have agreed that this is not a reasonable future land use inside the industrial use area. As shown in Figure 4-3, the industrial use area encompasses the tank farm boundary and contains all the OU 3-14 soil sites identified as present both inside and outside of the boundary. Therefore, residential

scenarios inside the industrial use area are considered incomplete for the OU 3-14 BRA (Figure 6-2). Risks from the other surface exposure routes calculated in the OU 3-13 BRA—inhalation of volatiles and particulates, incidental ingestion of surface soil, and dermal absorption, which are calculated from contaminant concentrations in the top 6 in. of soil—were conservatively estimated at far less than 1E-06 excess cancer risk and hazard quotient of 1 cumulatively for the tank farm. This was expected as most of the tank farm sites had releases that occurred below the 6-in. soil depth, making the 0 to 4-ft depth (direct gamma exposure) and deeper (groundwater) depths the only exposure pathways of concern. As a result, the additional sampling performed for the OU 3-14 RI/BRA was done at depths that could affect the direct exposure and groundwater exposure routes and did not specifically address the 0 to 6-in. depth interval. Therefore, based on the lack of new 0 to 6-in. soil sampling data and the fact that the soil risk calculated specifically from the 0 to 6-in. depth (ingestion, inhalation, and dermal absorption) contributed insignificant risk in OU 3-13, the exposure routes driven by the 0 to 6-in. soil depth were not recalculated for the OU 3-14 BRA.

In addition, the OU 3-13 BRA demonstrated that nonradiological contaminants made an insignificant contribution to risk relative to radionuclides. To confirm this, all new nonradiological sampling data (mostly nondetect) were screened for risk/hazard using EPA Region 9 preliminary remediation goals (PRGs). The results of this screening (Appendix I) confirmed that nonradiological contaminants are insignificant risk contributors at the tank farm soil sites, and they were, therefore, not evaluated further in the risk assessment.

7.2 HHRA Soil Pathway Methods

OU 3-14 soil includes the tank farm sites and contaminated backfill used in the tank farm, and two sites that are all or partially outside the tank farm boundary (CPP-15 and CPP-58). Evaluation of historical excavations within the tank farm indicates that contaminants in the surface soil have likely been mixed throughout the area (see Section 5.18). This means that sampling data from a particular site may or may not be related to the spill at that site. Because of this mixing of surface soil, it was decided to pool all sampling data for sites within the tank farm boundary (approximately 4 acres) for evaluation of surface soil risk. These sites (which will be referred to as Soil Inside Tank Farm Boundary) will include all OU 3-14 sites (including contaminated backfill in the tank farm) except for the two sites that contain area outside the tank farm boundary (Sites CPP-15 and CPP-58). Pooling all the sampling data for sites within the tank farm boundary also makes sense from an exposure scenario perspective, as it is improbable that any single receptor would remain over any single site for the duration of the exposure scenario (40 hours per week, 50 weeks per year, for 25 years). This assumption does not affect the groundwater pathway modeling and risk assessment, which uses the total activity inventory known to be released at each INTEC CERCLA site (see Section 8).

7.2.1 Exposure Assessment

The exposure assessment process estimates the exposure route, magnitude, frequency, and duration of receptor exposure to contaminants. The primary purpose of the exposure assessment is to estimate total dose (intake or external exposure) for a receptor that can be used to estimate the cancer risk and noncancer health effects. The conceptual site model (CSM) for the OU 3-14 RI/BRA (Figure 6-2) illustrates the primary contaminant sources and release mechanisms, secondary sources and release mechanisms, exposure pathways, exposure routes, and receptors specific to this risk assessment. A potentially complete (PC) exposure pathway/route means that the source, release mechanism, pathway, and exposure route are possible from contaminants at the tank farm. An incomplete (I) exposure pathway indicates that one or more of these criteria (e.g., source, exposure route, or receptor) do not exist and that there is no risk to a receptor. The CSM indicates incomplete exposure routes for current workers because it was agreed that significant exposure for current workers is not likely due to administrative controls

that currently exist on the tank farm. However, it was decided to evaluate a current worker scenario in the OU 3-14 BRA to facilitate remedial action decision-making. The exposure assessment process is described in Sections 7.2.1.1 through 7.2.1.4.

7.2.1.1 Identification of Potentially Exposed Receptor Populations. The identification of potentially exposed receptor populations includes consideration of applicable current and future land use scenarios.

Long-term land use assumptions were presented in the OU 3-14 Remedial Investigation/Feasibility Study (RI/FS) Work Plan (DOE-ID 2004). In summary, future occupational use (beyond year 2095) is a reasonably anticipated future land use scenario for the area inside the current INTEC security fence. Requirements for transfer of federal property, CERCLA 5-year reviews, institutional controls, and the presence of several designed permanent barrier systems together will make future residential land use within the tank farm area highly unlikely and will ensure that unacceptable exposure to soil and groundwater contamination does not occur. The Agencies have agreed that future residential use of the area inside the industrial use area (Figure 1-2) is not reasonable. Therefore, only occupational land use and, thus, both current and future worker exposure scenarios are assessed in this BRA.

The worker scenario assumes workers infrequently visit the tank farm under controlled access conditions and do not remain there for long periods of time. Therefore, exposures are minimized during the current land use, and a current long-term worker exposure scenario does not exist. However, to facilitate remedial action decision-making, a current worker scenario was evaluated for the Soil Inside the Tank Farm Boundary and separately for the two sites (CPP-15 and CPP-58) that extend beyond the tank farm boundary. All of these sites are located within the industrial use area shown in Figure 4-3.

7.2.1.2 Identification of Potential Exposure Pathways and Exposure Routes. In the OU 3-13 RI/BRA, all the soil exposure routes from contaminants in the upper 0 to 6 in. of the soil (inhalation of VOCs, inhalation of airborne particulates, and ingestion of surface soil) had calculated risks and hazard quotients far below levels of concern for the current and future worker (1E-06 risk and hazard quotient of 1). In addition, the risks from these exposure routes were seven orders of magnitude below the risk from the external radiation exposure route. Because the risks and hazards from contaminants in the upper 6 in. of soil were shown to be far below the levels of concern, no further depth-specific surface soil sampling for 0 to 6 in. was done for OU 3-14. Because there are no new 0 to 6–in. soil sampling data for refining the risk calculations, the risk results calculated in OU 3-13 for these exposure routes are still considered to be valid and are not further refined for OU 3-14. Therefore, direct exposure to radiation from radionuclides will be the only surface exposure route that is reevaluated in the OU 3-14 analysis. Ingestion of homegrown produce was not evaluated for the worker scenarios because produce is not and will not be grown in the industrial use area where all the sites are located. A summary of the exposure scenarios, pathways, and soil depths evaluated for the current and future worker scenarios evaluated is given in Table 7-2.

7.2.1.3 Derivation of Exposure-Point Concentrations. EPA recommends that the exposure point concentration (EPC) used to calculate risk at a site represents a reasonable estimate of the average concentration likely to be contacted over time. EPA guidance also states that because of the uncertainty associated with estimating the true average concentration at a site, the 95% upper confidence limit (95% upper confidence level [UCL]) of the arithmetic mean should be used for this variable (EPA 1992). The recently released EPA program, ProUCL (EPA 2006b), was used to calculate 95% UCLs of the sampling data for each of the site groupings evaluated (Soil Inside Tank Farm Boundary, CPP-15, and CPP-58) in the risk assessment. ProUCL (Version 3.00.02) provides advanced and improved methods for calculating the 95% UCLs compared to the traditionally used H-statistic method (H-UCL) which was previously specified by EPA (1992). In practice, for lognormal data sets with high standard deviation

Table 7-2. Summary of the surface exposure pathways evaluated in the OU 3-14 RI/BRA.

Potentially Exposed Receptor	Scenario	Evaluated for Sites	Exposure Pathways and Soil Depths
Occupational worker	Current land use	Soil Inside Tank Farm Boundary[a], CPP-15, CPP-58	External radiation (0-4 ft) Inhalation of airborne particulates (0-6 in.)[b] Ingestion of surface soil (0-6 in.)[b]
Occupational worker	Future land use	Soil Inside Tank Farm Boundary,[a] CPP-15, CPP-58	External radiation (0-4 ft) Inhalation of airborne particulates (0-6 in.)[b] Ingestion of surface soil (0-6 in.)[b]

a. All sites located entirely within the tank farm boundary (CPP-16, CPP-24, CPP-30, CPP-31, CPP-27/33, CPP-28, CPP-58W, CPP-79 [shallow and deep], CPP-20/25, CPP-26, and CPP-32 [E and W]) and the contaminated backfill.
b. OU 3-13 results are used because no new soil sampling exclusively from 0 to 6 in. was performed for OU 3-14 and because these pathways were shown to be insignificant risk drivers in OU 3-13.

(typical for INTEC soil sampling data sets), the traditional H-UCL can become unacceptably large and exceed the maximum observed concentration by orders of magnitude. This is especially true for skewed data sets of smaller sizes (e.g., $n < 50$). The H-UCL is also very sensitive to a few low or high values (also typical for our sampling data sets). ProUCL overcomes the problems of the H-UCL by using 5 parametric and 10 nonparametric methods to calculate the 95% UCL. The five parametric computational methods used in ProUCL are

1. Student's-t UCL
2. Approximate gamma UCL using chi-square approximation
3. Adjusted gamma UCL (adjusted for level significance)
4. Land's H-UCL
5. Chebyshev inequality based UCL.

Worker exposures to surface soil contaminants within the tank farm are evaluated by combining both historical and new sampling data from the 0 to 4-ft depth for the seven Soil Inside Tank Farm Boundary sites that are located completely within the tank farm: CPP-31, -27/33, -28, -79, -20/25, -26, and -32. Only new (2004) sampling data are available for CPP-31, -28, and -79. For CPP-27/33, both historical and new sampling data are available at the 0 to 4-ft level. Only historical data are available for the remaining sites, CPP-20/25, -26, and -32. Because of the lack of soil sampling in the area, soil concentrations from 11 samples were collected from stockpiled contaminated soil (1995) and were assumed representative of the soil beneath CPP-20/25 for risk assessment purposes. This is similar to the approach used in the OU 3-13 RI/BRA (DOE-ID 1997a). Worker exposures to the two sites outside the tank farm boundary, CPP-15 and CPP-58, are evaluated individually because the contaminants in those two sites are from different source types and are not contiguous. Both new (2004) and historical data are available for CPP-15, while only historical data are available for CPP-58. The 1995 sampling data for CPP-15 were not used in the analysis of impacts for that site because the surface soil was excavated to 10-ft depth and removed from the site after the sampling in 1995. Appendix I contains all sampling data used in the analysis.

Nonradiological contaminants detected during the 2004 sampling were screened against EPA Region 9 PRGs (EPA 2006c) (Appendix I), which indicated that the potential risk contributions from this class of contaminants would not be significant. Based on this screening analysis and the insignificant risk/hazard posed by these compounds determined in the OU 3-13 RI/BRA, nonradiological contaminants were not evaluated further.

The following steps were used to determine the EPCs for each radionuclide at each site:

- Extract (by site) radionuclide sampling data for the 0 to 4-ft depth from the Environmental Data Warehouse (EDW) database or from other sources such as Appendix G of the OU 3-13 BRA (pre-1997 sampling data). For evaluation of CPP-58, 0 to 10-ft data were extracted from those data sources.
- Eliminate data that were rejected per the method validation.
- Eliminate data that were flagged false positive due to data quality concerns such as high levels of contamination found in the blank.
- Segregate quality control data (e.g., blanks, duplicates).
- Average duplicate results.
- Evaluate the appropriateness of including nondetects at one-half the detection limit.
- Aggregate data by individual radionuclide.
- Calculate the 95% UCL of the arithmetic mean and the maximum of the sample concentrations for each radionuclide at each site.
- Select the lower of the 95% UCL or the maximum concentration (EPA 1992).

Radionuclide samples less than detection limits were evaluated at one-half the detection limit and determined to not affect the total calculated risk. Therefore, only samples greater than detection limit were evaluated to determine the EPC.

All sampling data were decay-corrected from the sampling date to the date of the most recent sampling (September 2004) for evaluation of the current worker scenario. For the future worker scenario, the data were further decay-corrected to 2095 (91 years after 2004). After decay-correcting the site concentrations to the start of each exposure scenario, an integrated average concentration over the receptor exposure duration (ED) was calculated to account for the radioactive decay that would occur over the ED. No other loss terms (e.g., leaching) were considered, which is a conservative assumption for surface exposure calculations.

The average soil concentration over the ED was calculated by integrating the soil concentration as a function of time over the ED and then dividing by the ED:

$$C_{ED} = \frac{C_s}{\lambda\ ED}\left(1 - e^{-\lambda\ ED}\right) \tag{7-1}$$

where

C_{ED} = integrated average radionuclide concentration in soil over the exposure duration (pCi/g)

C_s = 95% UCL of the mean or maximum soil concentration as determined by ProUCL (pCi/g)

λ = radionuclide decay constant (y^{-1}) = ln2/half-life

ED = exposure duration (years) = 25 for occupational.

7.2.1.4 Calculation of Direct External Radiation Exposure. The external radiation exposure is calculated for each individual contaminant using the following equation:

$$\text{Exposure (pCi yr/g)} = C_{soil} \times ET \times EF \times ED \times CF \quad (7\text{-}2)$$

where

C_{soil} = average contaminant concentration in soil over the exposure duration (pCi/g)

ET = exposure time (hr/d) = 10 for occupational

EF = exposure frequency (d/yr) = 200 for occupational

ED = exposure duration (yr) = 25 for occupational

CF = conversion factor (1.14×10^{-4} yr/hr).

Equation (7-2) applies to outdoor exposures only, which is the likely exposure condition for workers. Indoor exposures would be less than that calculated using Equation (7-1) because of shielding provided by the building. Although buildings are on the tank farm, the frequency or amount of time workers spend in those buildings cannot be quantified and is likely to be small compared to their time outdoors. Therefore, Equation (7-2) provides a conservative assessment of direct gamma exposure for workers. EPA typically assumes a gamma shielding factor (GSF) of 0.4, which would reduce the amount of direct radiation exposure for a given time to 40% of what it would be if the individual remained outdoors over the contaminated source (EPA 2000). Because the amount of time a worker spends indoors on the tank farm is unknown and likely to be low, application of a GSF for calculation of worker risks is not considered appropriate. No area correction factor (reduction in exposure rate because of limited source geometry) was applied because the source geometry is representative of an infinite slab (contamination deeper than 15 cm and areal extent exceeding 1,000 m^2).

7.2.2 Toxicity Assessment

EPA classifies all radionuclides as known human cancer-causing agents (Group A carcinogens), based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of radiogenic cancers in humans. At Superfund radiation sites, EPA generally evaluates potential human health risks based on the radiotoxicity, i.e., adverse health effects caused by ionizing radiation, rather than on the chemical toxicity, of each radionuclide present. These evaluations consider the carcinogenic effects of radionuclides only. In most cases, cancer risks are limiting, exceeding both mutagenic and teratogenic risks.

For the OU 3-14 BRA, radionuclide SFs for converting external exposure to lifetime risk of cancer incidence are taken from EPA's HEAST—Radionuclides Table (EPA 2006a), formerly HEAST Table 4. Radionuclide SFs are calculated for each radionuclide individually, based on its unique chemical, metabolic, and radioactive properties. The calculation methodology is documented in Federal Guidance Report No. 13 (EPA 1999). The risk coefficients derived in Federal Guidance Report No. 13 and used to calculate the SFs presented in the Radionuclide Tables are based on state-of-the-art methods and models that take into account the age- and gender-dependence of radionuclide intake, metabolism, dosimetry,

radiogenic risk, and competing causes of death in estimating the cancer risk from low-level exposures to radionuclides in the environment. The risk coefficients in Federal Guidance Report No. 13 are estimates of the probability of radiogenic cancer mortality (fatal cancers) or morbidity (fatal plus nonfatal cancers) per unit activity of a given radionuclide inhaled or ingested for internal exposure, or per unit time-integrated activity concentration in air or soil for external exposure. These risk coefficients may be interpreted either as the average risk per unit exposure for persons exposed throughout their lifetime to a constant activity concentration of a radionuclide in an environmental medium (air or soil) or as the average risk per unit exposure for persons exposed for a brief period to the radionuclide in an environmental medium. These risk coefficients are based on the age and gender distributions and the mortality characteristics of the 1989–1991 U.S. decennial life tables.

External exposure SFs are central estimates of lifetime attributable radiation cancer incidence risk for each year of exposure to external radiation from photon-emitting radionuclides distributed uniformly in a thick layer of soil and are expressed as risk/yr per pCi/g soil. The HEAST radionuclide external SFs used for the OU 3-14 BRA are listed in Table 7-3.

Table 7-3. HEAST slope factors used for evaluating cancer morbidity due to external exposure from radionuclides.

Radionuclide	External Contaminant External Exposure Slope Factor (CSF) (risk/yr per pCi/g)
Am-241	2.76E-8
Co-60	1.24E-5
Cs-134	7.10E-6
Cs-137 +D	2.55E-6
Eu-154	5.83E-6
Np-237	5.36E-8
Pu-238	7.22E-11
Pu-239	2.00E-10
Pu-239/240	6.98E-11
Sr-90+D	1.96E-8
Tc-99	8.14E-11
U-234	2.52E-10
U-235+D	5.43E-7
U-238+D	1.14E-7

7.2.3 Risk Characterization

Risk characterization is the calculation of the magnitude of the potential adverse effects of the contaminants of concern (COCs) and summarizing the risks to public health. Risk characterization combines the results of the exposure and toxicity assessments to quantify the health risk. The process of characterizing risk from direct exposure to radionuclides in the surface soil includes the following:

- Calculate and characterize cancer risk
- Conduct qualitative uncertainty analysis.

The carcinogenic risk for each individual contaminant is calculated by multiplying a contaminant's calculated exposure (Section 7.2.1.4) by the SF for that contaminant (Table 7-3):

$$\text{Risk} = \text{Exposure} \times \text{CSF} \qquad (7\text{-}3)$$

where

Risk = potential lifetime excess cancer risk (unitless) for each contaminant

Exposure = direct radiation exposure (pCi – yr)/g)

CSF = contaminant external exposure slope factor (risk/yr per pCi/g).

The total cancer risk from all contaminants is calculated by summing the calculated risks for all the radionuclides considered in the risk assessment. The risk summation assumes independence of action by the radionuclides involved. Limitations posed by using this approach are discussed in the EPA's risk assessment guidance (EPA 1989). In accordance with EPA guidance, only one significant digit is retained when summarizing calculated risks (EPA 1989). The total risk from all exposure routes will be calculated by adding the inhalation and ingestion risks calculated in the OU 3-13 BRA to the direct exposure risks calculated in the OU 3-14 BRA.

7.2.4 Uncertainty Analysis

Sources of uncertainty introduced in the risk assessment process range from the site field investigation, sampling and analysis, through the risk characterization. The intent of this section is to qualitatively describe the various aspects of uncertainty for the different steps in the risk assessment. Site-specific uncertainty is discussed in the results section.

7.2.4.1 Site Characterization. The characterization of the contaminated sites varies from site to site and is discussed in the results sections. The uncertainty in site characterization is a function of the amount of information available regarding the original release, the number of soil samples collected at a site, variability in the spatial distribution of contaminants at a site, and measurement error in the analytical methods. This uncertainty is compensated for by using the 95% UCL of the mean or maximum of the sample concentrations, which likely results in an overestimate of the average concentrations that a receptor would be exposed to.

7.2.4.2 Contaminants of Potential Concern. All radionuclides detected at greater-than-detection limits are evaluated for risk in the OU 3-14 BRA. Therefore, there is no uncertainty from elimination of radionuclides through a screening process that is normally employed

for BRAs. Screening performed for nonradiological contaminants indicated that these contaminants (mostly nondetect) would not significantly contribute to risk (Appendix I).

7.2.4.3 Exposure Routes. Based on the results of the OU 3-13 BRA, the only significant surface exposure route for the tank farm soil to workers is from external radiation. Because the risk estimate from external radiation (0.06 to 0.6) was much greater than the acceptable risk-based level (1E-04) and many orders of magnitude greater than the other surface exposure routes (e.g., soil ingestion and inhalation) and because no new data were obtained for the soil layer that drives these other pathways, a reevaluation of the soil ingestion or inhalation exposure routes in the OU 3-14 BRA would likely not change the final risk results.

7.2.4.4 Exposure-Point Concentration. The EPCs used for assessing risks associated with the reasonable maximum exposure case are high-end estimates of the mean site COPC concentrations, either the maximum detected value or the 95% UCL (whichever is less).

7.2.4.5 Exposure Levels. The amount of exposure that an individual receives is highly dependent on his/her activity patterns and the amount of time an individual spends at a particular site. Many of the sites are only occasionally visited by site workers, and their exposure time is likely to be significantly lower than the values assumed in the exposure assessment (i.e., 10 hours per day, 200 days per year for 25 years). Therefore, it is likely that the exposure and risk calculated in this risk assessment overestimate the actual worker impacts. Another factor that affects the calculated risk is the amount of time an individual spends indoors since the building structure provides some shielding of direct radiation. EPA typically assumes a GSF of 0.4, which would reduce the amount of direct radiation exposure for a given time to 40% of what it would be if the individual remained outdoors over the contaminated source (EPA 2000). Because the amount of time a worker spends indoors on the tank farm is unknown and likely to be low, a GSF was not applied.

7.2.4.6 Cancer-Risk Factors. EPA classifies all radionuclides as Group A carcinogens, based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of radiogenic cancers in humans. The toxicity factors (i.e., SFs) used to calculate cancer risk from exposure to radionuclides are therefore generally more reliable than those used for chemicals, which are often extrapolated from animal studies. The radionuclide SFs are derived from risk coefficients in Federal Guidance Report No. 13 and are based on state-of-the-art methods and models that take into account the age- and gender-dependence of radionuclide intake, metabolism, dosimetry, radiogenic risk, and competing causes of death in estimating the cancer risk.

7.2.4.7 Multiple Contaminant Exposures. The risk assessment approach assumes that health risks from multiple contaminants are additive, ignoring both synergistic and antagonistic effects among contaminants. There are insufficient experimental studies to quantify these effects.

7.3 HHRA Soil Pathway Results

This section summarizes the risk assessment results from direct exposure to radionuclides in surface soil at the tank farm. Risk assessment calculations were made separately for the following sites:

- Soil Inside Tank Farm Boundary. This includes all sampling data for the sites located completely within the tank farm boundary. These sites were evaluated together (sampling data for all sites were combined) because of widespread surface soil mixing within the tank farm as a result of excavations that occurred after the spills at the individual sites. Both current (2004–2029) and future (2095–2120) worker scenarios were evaluated, which were calculated from pooled 0 to 4-ft soil sampling data from these sites.

- CPP-15 and CPP-58. Risks were calculated individually for each site because the sites are not contiguous and the spills that occurred at each site were unrelated. Individual risk calculations for each site will also facilitate remedial action decision-making. For CPP-15, worker risks were calculated from radionuclide concentrations in the top 0 to 4 ft of soil. For CPP-58, worker risks were calculated using sampling data from 6- to 10-ft depth since there are no 0 to 4-ft sampling data available for this site.

7.3.1 Sampling Data Summary Statistics

Soil Inside Tank Farm Boundary. Summary statistics for the 0 to 4-ft data available for the Soil Inside Tank Farm Boundary are presented in Table 7-4. The results are compared to the 95% upper tolerance limit (UTL) of the background concentrations for each radionuclide if available (INEL 1996). If all samples for a radionuclide are less than the 95% UTL background concentration, then that radionuclide is excluded from risk assessment. Relatively high concentrations occurred for Cs-137, Pu-238, Sr-90, and Am-241. The 95% UCL for Cs-137 was driven by a 1992 sample from CPP-26 (4,823 pCi/g) and a 2004 sample from CPP-28 (1,069 pCi/g) (Table 7-5). Only U-238 (maximum = 1.02 pCi/g) was less than background (1.04 pCi/g).

CPP-15. Summary statistics for the 0 to 4-ft sampling data available for CPP-15 are presented in Table 7-6.

CPP-58. Summary statistics for the 6- to 10-ft sampling data available for CPP-58 are presented in Table 7-7. At these depths, concentrations were elevated for Sr-90, Pu-238, and Cs-137. The Cs-137 EPC was driven by one 1992 sample (32.8 pCi/g) (Table 7-8). Pu-239 and U-234 were less than background.

7.3.2 Risk Assessment

This section contains the results of the tank farm soils risk assessment. Risks due to external radiation exposure were calculated for all radionuclides detected in surface soil sampling since 1992. Risks due to other occupational exposure routes (ingestion of soil, inhalation) were taken from the OU 3-13 RI/BRA since these exposure routes have been shown to be very small compared to external exposure. Also no new sampling data were obtained in 2004 specifically in the surface soil layer (0-6 in.) from which the ingestion and inhalation routes are calculated. Risks were calculated separately for receptors at three locations: (1) Soil Inside Tank Farm Boundary, (2) CPP-15, and (3) CPP-58. The latter two sites were calculated separately because they extend beyond the tank farm boundary and because the contamination at those sites is from separate, unrelated spills.

7.3.2.1 Soil Inside Tank Farm Boundary. Tables 7-9 and 7-10 present the current and future worker scenario risk results for the Soil Inside the Tank Farm Boundary, located completely within the tank farm boundary (including the contaminated backfill and all OU 3-14 sites except CPP-15 and CPP 58). The total current worker risk, 2E-02, and total future worker risk, 3E-03, are both solely due to external radiation or direct exposure from Cs-137. Eu-154 contributes about 0.1% to the total current worker risk, with the remaining radionuclides and exposure routes (ingestion of soil, inhalation) making an insignificant contribution. Both of these risk results significantly exceed the risk criteria of 1E-04 established in the OU 3-13 ROD (DOE-ID 1999a).

7.3.2.2 CPP-15. Tables 7-11 and 7-12 present the current and future worker risk results for CPP-15. The total risks—7E-04 current worker and 8E-05 future worker—are almost entirely due to external radiation exposure from Cs-137. Therefore, the current worker risk scenario for CPP-15 exceeds the risk criteria of 1E-04 established in the OU 3-13 ROD.

Table 7-4. Summary sampling statistics for Soil Inside the Tank Farm Boundary, 0 to 4-ft depth.

			Soil Concentration (pCi/g)[a]					
COPC[b]	Number of Detects	Number of Samples	Minimum Detected	Maximum Detected	UCL of the Mean	UCL Method	INL Site Background[c]	Less than Background?
Am-241	9	21	0.0362	2.0	1.02	Student's-T	0.011	No
Co-60	1	13	0.027	0.027	0.027	Maximum	N/A	N/A
Cs-134	2	14	0.0059	0.0086	0.00876	Maximum	N/A	N/A
Cs-137	24	28	0.048	4,823	1,848	97.5% Chebyshev	0.82	No
Eu-154	9	20	0.060	3.94	1.52	95% Chebyshev	N/A	N/A
Np-237	7	17	0.10	0.17	0.15	Student's-T	N/A	N/A
Pu-238	15	22	0.10	3.24	3.17	Student's-T	0.0049	No
Pu-239/240	7	19	0.030	0.841	0.610	Approx gamma	0.10	No
Sr-90	13	14	5.3	265	89	Approx gamma	0.49	No
Tc-99	12	14	0.9	3.4	2.0	Approx gamma	N/A	N/A
U-234	20	20	0.09	2.21	1.08	Student's-T	1.44	No
U-235	6	20	0.021	0.104	0.075	Student's-T	N/A	No
U-238	13	17	0.50	1.02	0.88	Student's-T	1.40	Yes

a. Decayed to 9/2004 (date of most recent sampling).
b. Only radiological contaminants are included. Nonradiological contaminants (mostly nondetect) were screened from further analysis in Appendix I.
c. 95% UTL from INEL (1996).
N/A = not applicable.

Table 7-5. Soil sampling results for Cs-137 for Soil Inside the Tank Farm Boundary, 0 to 4-ft depth.

Location	Sample Depth (ft)	Sample Number	Date	Lab Results (pCi/g)	Concentration 2004 (pCi/g)
CPP-26-3	1.0-1.8	30700701	1/1/1992	108	80.6
CPP-26-3	1.8-2.7	30700801	1/1/1992	259	193
CPP-26-3	1.8-2.7	30700901	1/1/1992	176	131
CPP-26-1	3.8-4.7	30700101	1/1/1992	6,460	4,823
CPP-32E-1	1.4-2.3	30701001	1/1/1992	277	207
CPP-32E-1	2.2-2.9	30701101	1/1/1992	151	113
CPP-32E-1	2.2-2.9	30701201	1/1/1992	133	99.3
CPP-27-1	2.0-4.0	30800101	9/23/1992	4.62	3.51
CPP-27-3	2.0-4.0	30801701	9/22/1992	0.739	0.561
CPP-20/25	1-1.5	3CS00101EH	6/28/1995	3.81	3.08
CPP-20/25	1-1.5	3CS00301EH	6/28/1995	15.2	12.3
CPP-20/25	1-1.5	3CS00501EH	6/28/1995	73.4	59.4
CPP-20/25	1-1.5	3CS01001EH	6/28/1995	32.8	26.5
CPP-20/25	1-1.5	3CS01101EH	6/28/1995	29.3	23.7
CPP-20/25	1-1.5	3CS00901EH	6/28/1995	11.4	9.22
CPP-20/25	1-1.5	3CS00701EH	6/28/1995	36.4	29.4
CPP-20/25	1-1.5	3CS00801EH	6/28/1995	25.9	21.0
CPP-20/25	1-1.5	3CS00201EH	6/28/1995	114	92.2
CPP-20/25	1-1.5	3CS00401EH	6/28/1995	9.6	7.8
CPP-20/25	1-1.5	3CS00601EH	6/28/1995	22	18
CPP-31	0-4	E0510403601RH	8/24/2004	214	214
CPP-27	0-4	E0510401201RH	8/12/2004	0.0482	0.048
CPP-28	0-4	E0510402401RH	8/18/2004	1,070	1,069
CPP-79	0-4	E0510404801RH	9/7/2004	29.8	29.8
				Min (pCi/g) =	0.0481
				Max (pCi/g) =	4,823
				97.5% Chebyshev UCL (pCi/g) =	1,848

Table 7-6. Summary statistics for CPP-15, 0 to 4-ft depth.

COPC[a]	Number of Detects	Number of Samples	Soil Concentration (pCi/g)	INL Site Background[b]	Less than Background?
Am-241	1	1	0.04	0.011	No
Cs-137	1	1	59	0.82	No
Pu-238	1	1	0.33	0.0049	No
Pu-239/240	1	1	0.03	0.10	Yes
Sr-90	1	1	26.7	0.49	No
U-234	1	1	0.59	1.44	Yes
U-235	1	1	0.04	N/A	No
U-238	1	1	0.65	1.40	Yes

a. Only radiological contaminants are included. Nonradiological contaminants (mostly nondetect) were screened from further analysis in Appendix I.
b. 95% UTL from INEL (1996).
N/A = not applicable.

Table 7-7. Summary statistics for CPP-58, 6- to 10-ft depth[a].

			Soil Concentration (pCi/g)[b]					
COPC[c]	Number of Detects	Number of Samples	Minimum Detected	Maximum Detected	UCL of the Mean	UCL Method	INL Site Background[d]	Less than Background?
Am-241	1	1	0.10	0.10	0.10	Maximum	0.011	No
Cs-137	4	4	7.4	36.8	36.8	Maximum	0.82	No
Eu-154	1	1	0.06	0.06	0.06	Maximum	N/A	N/A
Pu-238	1	1	0.27	0.27	0.27	Maximum	0.0049	No
Pu-239/ -240	1	1	0.04	0.04	0.04	Maximum	0.10	Yes
Sr-90	4	4	2.9	25	25	Maximum	0.49	No
U-234	1	1	1.13	1.13	1.13	Maximum	1.44	Yes
U-235	1	1	0.068	0.068	0.068	Maximum	N/A	No

a. No data are available for this site at the worker 0 to 4-ft depth interval; therefore, available 6- to 10-ft sampling data from 1992 were used.
b. Decayed to 9/2004 (date of most recent sampling).
c. Only radiological contaminants are included. Nonradiological contaminants (mostly nondetect) were screened from further analysis in Appendix I.
d. 95% UTL given in INEL (1996).
N/A = not applicable.

Table 7-8. CPP-58 0 to 10-ft soil sampling results for Cs-137.

Location	Sample Depth (ft)	Sample Number	Date	Lab Results (pCi/g)	Concentration 2004 (pCi/g)
CPP-58E-1	6-8	30804901	9/17/1992	43.2	32.8
CPP-58E-2	6-8	30806001	9/16/1992	9.8	7.4
CPP-58E-1	8.0-10.0	30805001	9/17/1992	48.5	36.8
CPP-58E-2	8.0-10.0	30806101	9/16/1992	20.7	15.7
				Min (pCi/g) =	7.4
				Max (pCi/g) =	36.8
				ProUCL recommended (pCi/g) =	36.8

Table 7-9. Current worker scenario risk assessment results for Soil Inside the Tank Farm Boundary.

COPC	Concentration Term (pCi/g)[a]	ED-Averaged Concentration[b] (pCi/g)	Direct Radiation Exposure (pCi-yr/g)	Direct Radiation Risk	Other Exposure Route Risk[c]
Am-241	1.02	1.00	5.72	1.6E-07	---
Co-60	0.027	0.0079	0.045	5.6E-07	---
Cs-134	0.009	0.001	0.006	4.1E-08	---
Cs-137	1,848	1,405	8,008	2.0E-02	5.0E-08
Eu-154	1.52	0.664	3.79	2.2E-05	---
Np-237	0.15	0.15	0.85	6.8E-07	---
Pu-238	3.17	2.88	16.4	4.5E-07	---
Pu-239	0.61	0.61	3.5	6.9E-10	---
Sr-90	89	67	380	1.8E-07	2.0E-08
Tc-99	2.01	2.01	11.5	9.3E-10	---
U-234	1.08	1.08	6.2	1.6E-09	---
U-235	0.075	0.075	0.43	2.3E-07	---
U-238	d	d	d	d	d
Total	N/A	N/A	N/A	2E-02	7E-08

a. 95% UCL or maximum of the 0 to 4-ft sampling data decayed to start of the exposure scenario (2004).
b. 25-year average of the integrated concentration (with decay) over the ED (see Section 7.2.1.3).
c. Sum of risks from soil ingestion and inhalation taken from both the Tank Farm Group and Tank Farm South Group sites in OU 3-13 RI/BRA (DOE-ID 1997a).
d. Less than background (see Table 7-4).
"---" indicates no data available and not calculated in OU 3-13.
N/A = not applicable.

Table 7-10. Future worker scenario risk assessment results for Soil Inside the Tank Farm Boundary.

COPC	Concentration Term (pCi/g)[a]	ED-Averaged Concentration[b] (pCi/g)	Direct Radiation Exposure (pCi-yr/g)	Direct Radiation risk	Other Exposure Route Risk[c]
Am-241	0.89	0.87	4.9	1.4E-07	---
Co-60	1.7E-07	5.0E-08	2.9E-07	3.6E-12	---
Cs-134	4.4E-16	5.2E-17	3.0E-21	2.1E-21	---
Cs-137	227	173	985	2.5E-03	5.0E-09
Eu-154	1.2E-03	5.1E-04	2.9E-03	1.7E-08	---
Np-237	0.15	0.15	0.85	6.8E-07	---
Pu-238	1.5	1.4	8.0	2.2E-07	---
Pu-239	0.61	0.61	3.5	6.9E-10	---
Sr-90	10.2	7.7	44	2.1E-08	2.0E-09
Tc-99	2.01	2.01	11.5	9.3E-10	---
U-234	1.08	1.08	6.2	1.6E-09	---
U-235	0.075	0.075	0.43	2.3E-07	---
U-238	d	d	d	d	d
Total	N/A	N/A	N/A	3E-03	7E-09

a. 95% UCL or maximum of the 0 to 4-ft sampling data decayed to start of the exposure scenario (2095).
b. 25-year average of the integrated concentration (with decay) over the ED (see Section 7.2.1.3).
c. Sum of risks from soil ingestion and inhalation taken from both the Tank Farm Group and Tank Farm South Group sites in OU 3-13 RI/BRA (DOE-ID 1997a).
d. Less than background (see Table 7-4).
"---" indicates no data available and not calculated in OU 3-13.
N/A = not applicable.

Table 7-11. CPP-15 risk assessment results for the current worker exposure scenario (0 to 4-ft soil depth).

COPC	Concentration Term (pCi/g)[a]	ED-Averaged Concentration[b] (pCi/g)	Direct Radiation Exposure (pCi-yr/g)	Direct Radiation Risk	Other Exposure Route Risk[c]
Am-241	0.04	0.04	0.22	6.2E-09	---
Cs-137	59	45	254	6.5E-04	5.0E-08
Pu-238	0.33	0.30	1.7	1.2E-10	---
Pu-239	d	d	d	d	d
Sr-90	27	20	115	5.5E-08	2.0E-08
U-234	d	d	d	d	d
U-235	0.039	0.039	0.223	1.2E-07	---
U-238	d	d	d	d	d
Total	N/A	N/A	N/A	7E-04	7E-08

a. Maximum of the 2004 0 to 4-ft sampling data.
b. 25-year average of the integrated concentration (with decay) over the ED (see Section 7.2.1.3).
c. Sum of risks from soil ingestion and inhalation taken from the Tank Farm South Group sites in OU 3-13 RI/BRA (DOE-ID 1997a).
d. Less than background (see Table 7-6).
"---" indicates no data available and not calculated in OU 3-13.
"N/A" = not applicable.

Table 7-12. CPP-15 risk assessment results for the future worker exposure scenario (0 to 4-ft soil depth).

COPC	Concentration Term (pCi/g)[a]	ED-Averaged Concentration[b] (pCi/g)	Direct Radiation Exposure (pCi-yr/g)	Direct Radiation Risk	Other Exposure Route Risk[c]
Am-241	0.035	0.034	0.19	5.4E-09	---
Cs-137	7.2	5.5	31	8.0E-05	5.0E-09
Pu-238	0.16	0.14	0.82	5.9E-11	---
Pu-239	d	d	d	d	d
Sr-90	3.1	2.3	13	6.3E-09	2.0E-09
U-234	d	d	d	d	d
U-235	0.039	0.039	0.22	1.2E-07	---
U-238	d	d	d	d	d
Total	N/A	N/A	N/A	8E-05	7E-09

a. Maximum of the 2004 0 to 4-ft sampling data decayed to start of the exposure scenario (2095).
b. 25-year average of the integrated concentration (with decay) over the ED (see Section 7.2.1.3).
c. Sum of risks from soil ingestion and inhalation taken from the Tank Farm South Group sites in OU 3-13 RI/BRA (DOE-ID 1997a).
d. Less than background (see Table 7-6).
"---" indicates no data available and not calculated in OU 3-13.
"N/A" = not applicable.

7.3.2.3 CPP-58. Tables 7-13 and 7-14 present the current and future worker risk results for CPP-58 using the available 6- to 10-ft sampling data. The total current worker risk of 4.1E-04 is almost entirely due to external radiation exposure from Cs-137 with a small contribution from other exposure routes, primarily soil ingestion of Cs-137 (4E-06), as calculated in the OU 3-13 RI/BRA (DOE-ID 1997a). The risk estimates taken from the OU 3-13 RI/BRA for these other exposure routes are very conservative for application at CPP-58 because the OU 3-13 risk estimates are for all of the Tank Farm South sites grouped together, which includes area-weighted concentrations from CPP-15, CPP-27/33, CPP-58, and CPP-88 (interstitial soil). However, this conservatism does not impact total calculated risk for this site, which is driven by Cs-137 external radiation exposure. The current worker risk (4.1E-04) exceeds the risk criteria (1E-04) by a factor of 4.

Table 7-13. CPP-58 risk assessment results for the current worker exposure scenario (using available 6- to 10-ft soil sampling data).

COPC	Concentration Term (pCi/g)[a]	ED-Averaged Concentration[b] (pCi/g)	Direct Radiation Exposure (pCi-yr/g)	Direct Radiation Risk	Other Exposure Route Risk[c]
Am-241	0.099	0.097	0.55	1.5E-08	1.0E-07
Cs-137	37	28	160	4.1E-04	5.0E-06
Eu-154	0.060	0.026	0.15	4.1E-09	7.1E-13
Np-237	---	---	---	---	2.0E-09
Pu-238	0.27	0.24	1.4	3.8E-08	3.0E-08
Pu-239	d	d	d	d	d
Sr-90	25	19	108	5.2E-08	6.0E-07
Tc-99	---	---	---	---	1.0E-07
U-234	d	d	d	d	d
U-235	0.0679	0.0679	0.387	1.1E-08	2.2E-09
Total	N/A	N/A	N/A	4E-04	6E-06

a. 95% UCL or maximum of the sampling data decayed to start of the exposure scenario (2004).
b. 25-year average of the integrated concentration (with decay) over the ED.
c. Sum of risks from soil ingestion and inhalation taken from the Tank Farm South Group sites in OU 3-13 RI/BRA (DOE-ID 1997a).
d. Less than background (see Table 7-7).
"---" indicates no data available.
"N/A" = not applicable.

The total risk for the future worker exposure scenario at CPP-58 is 5.6E-05, most of which is due to Cs-137 direct radiation (Table 7-14). This is less than the 1E-04 risk criteria.

Table 7-14. CPP-58 risk assessment results for the future worker exposure scenario (using available 6- to 10-ft soil sampling data).

COPC	Concentration Term (pCi/g)[a]	ED-Averaged Concentration[b] (pCi/g)	Direct Radiation Exposure (pCi-yr/g)	Direct Radiation Risk	Other Exposure Route Risk[c]
Am-241	0.086	0.084	0.48	1.3E-08	1.0E-07
Cs-137	4.5	3.4	20	5.0E-05	5.0E-06
Eu-154	4.6E-05	2.0E-05	1.2E-04	3.2E-12	7.1E-13
Np-237	---	---	---	---	2.0E-09
Pu-238	0.13	0.12	0.68	1.9E-08	3.0E-08
Pu-239	d	d	d	d	d
Sr-90	2.9	2.2	12	6.0E-09	6.0E-07
Tc-99	---	---	---	---	1.0E-07
U-234	d	d	d	d	d
U-235	0.068	0.068	0.39	1.1E-08	2.2E-09
Total	N/A	N/A	N/A	5E-05	6E-06

a. 95% UCL or maximum of the sampling data decayed to start of the exposure scenario (2095).
b. 25-year average of the integrated concentration (with decay) over the ED.
c. Sum of risks from soil ingestion and inhalation taken from the Tank Farm South Group sites in OU 3-13 RI/BRA (DOE-ID 1997a).
d. Less than background (see Table 7-7).
"---" indicates no data available.
"N/A" = not applicable.

7.3.2.4 Uncertainties.

7.3.2.4.1 Site Characterization and Exposure Point Concentrations—

Uncertainty in site characterization is a function of the amount of information available regarding the number of soil samples collected at a site, variability in the spatial distribution of contaminants at a site, and measurement error in the analytical methods. This uncertainty is compensated for in this risk assessment by using the 95% UCL of the mean or maximum of the sample concentrations, which likely results in an overestimate of the average concentrations that a receptor would be exposed to.

For the Soil Inside the Tank Farm Boundary, site characterization at the 0 to 4-ft depth is reasonably good with a total of 24 Cs-137 samples obtained at greater-than-detection limit. The data were found to be lognormal using ProUCL, which calculated a 97.5% Chebyshev UCL of 1,848 pCi/g (in 2004). It is possible that this UCL may be high for the entire tank farm area given that it was driven by two relatively high samples (4,823 pCi/g and 1,069 pCi/g, decayed to 2004) at CPP-26 and CPP-28. If these two samples are eliminated from the analysis, ProUCL calculates an approximate gamma UCL of 109 pCi/g for the remaining 22 samples. This would decrease the total risk for Soil Inside Tank Farm Boundary from 3E-03 (future worker scenario) to 1.7E-04. However, this still slightly exceeds the risk criteria of 1E-04. Therefore, site characterization uncertainty would not likely change the risk assessment conclusions for Soil Inside Tank Farm Boundary.

For CPP-58, no samples were available at the 0 to 4-ft depth, and only four Cs-137 samples were available for the 6- to 10-ft depth. No additional sampling was performed for this site in 2004. The worker scenario risks were therefore calculated using the available 6- to 10-ft sampling data. There is significant uncertainty associated with the worker risk estimates using these data because (1) it is not known whether the 0 to 4-ft surface soil that workers would be exposed to is at a higher or lower concentration and (2) the risks, which were mostly due to Cs-137 direct gamma exposure, will be strongly influenced by the depth of contamination due to soil shielding. However, this site has been extensively excavated, and contaminated soil has been removed when encountered at depths that occupational workers would be exposed to.

7.3.2.4.2 Contaminants of Potential Concern—All radionuclides detected at greater-than-detection limits were evaluated in the OU 3-14 BRA. Therefore, there is no uncertainty from elimination of radionuclides through a screening process that is normally employed in BRAs. Also, there is little uncertainty in the final total risk results from not reevaluating nonradiological (i.e., metal and organic) contaminants, as this group of contaminants contributed insignificant risk relative to Cs-137 in the previous OU 3-13 RI/BRA. Since no new (2004) sampling data were obtained at the depth (0 to 0.5 ft) that drive the inhalation and ingestion exposure routes from these contaminants, the relative risk impacts from these contaminants remain inconsequential.

7.3.2.4.3 Exposure Routes—Based on the results of both the OU 3-13 RI/BRA and this risk assessment, the only significant surface exposure route for the OU 3-14 soil to both workers and future residents is from external radiation. Because the risk estimate from external radiation (3E-03 to 2E-02 for workers at Soil Inside Tank Farm Boundary) was much greater than the cleanup risk criteria (1E-04) and many orders of magnitude greater than the other surface exposure routes (e.g., soil ingestion and inhalation) calculated in the OU 3-13 RI/BRA, the reevaluation of only the external radiation exposure route does not likely contribute to uncertainty in the final OU 3-14 surface soil risk results and conclusions.

7.3.2.4.4 Exposure Levels—The amount of exposure that an individual receives is highly dependent on his/her activity patterns and the amount of time an individual spends at a particular site. Many of the sites are only occasionally visited by site workers, and the exposure time is significantly lower than the values used in the exposure assessment (i.e., 10 hours per day, 200 days per year for 25 years). Therefore, it is likely that the exposure and risk calculated in this risk assessment overestimate the actual worker impacts.

To account for shielding of gamma radiation by building materials while an individual is indoors, the calculated risk for the future worker would be reduced using a GSF of 0.4 (EPA 2000). Application of this GSF for worker exposures at CPP-58 would reduce the current risk from 4.1E-04 to 1.6E-04 and the future risk from 5.6E-05 to 2.2E-05. However, application of a GSF to reduce worker exposures at sites within the industrial use area around the tank farm may not be appropriate because most of the worker presence there is anticipated to be associated with outdoor activities.

7.3.2.5 Conclusions and Recommendations. The results of this risk assessment under current land use indicate that worker exposures at both the Soil Inside the Tank Farm Boundary (2E-02) and Site CPP-15 (7E-04) are well above the risk criteria (1E-04) established in the OU 3-13 ROD (DOE-ID 1999a). Under future land use (beginning in 2095), Soil Inside Tank Farm Boundary still pose worker risks (3E-03) that are well above the risk criteria, indicating that some type of response action is needed at these sites to mitigate adverse impacts to human health. The future worker risk at CPP-15 (8E-05) is slightly less than the risk criteria.

Potential worker risks at CPP-58 under current exposure conditions (4E-04) exceed the risk criteria by a factor of 4 but, under the future exposure scenario (5E-05), are less than the risk criteria by a factor of 2. However, these risk estimates are highly uncertain because they are based on available sampling data which are at deeper depths (6 to 10 ft) than the 0 to 4-ft depth, which should be used for assessing worker exposure. Additional sampling at the 0 to 4-ft depth would reduce the uncertainty associated with this site assessment. However, this site has been extensively excavated.

7.4 Ecological Risk Assessment Approach

The ERA performed in the OU 3-13 RI/FS is presented in Section 28 of DOE-ID (1997b). The OU 3-13 ERA follows the approach presented in the *Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL* (VanHorn, Hampton, and Morris 1995) and uses the 0 to 10-ft depth for evaluation, similar to the HHRA for residential intrusional scenario. The results of this assessment found that several metals and radionuclides are potentially at levels of concern. Because of the availability of new sampling data and updated input parameters for ecological receptors available from EPA (EPA 2006d) and as documented in the OU 10-04 Comprehensive RI/FS (DOE-ID 2001), these data were reassessed to ensure that the conclusions made in the OU 3-13 RI/FS are still valid.

Data in the 0 to 10-ft range were compiled using the HHRA approach.. Initial screening of contaminants was performed. Those COPCs and radionuclides of potential concern that exceeded screening were further evaluated using the approach documented in the OU 10-04 Comprehensive RI/FS (DOE-ID 2001). The initial screening is discussed below.

7.4.1 Background Comparison

As performed in the human health chemical screening, the first step in the ecological screening process is to distinguish potential contamination associated with the site from naturally occurring background conditions. The comparison is primarily conducted using the composite background values from Rood, Harris, and White (1996) or from other sources, as identified.

7.4.2 Essential Nutrient Identification

Step 2 of the ecological screening process is an essential nutrient analysis. Site chemicals that are considered essential nutrients are not evaluated further unless the concentration is greatly in excess of the background value (10 times). The six metals routinely eliminated by this screening step are aluminum, calcium, iron, magnesium, potassium, and sodium (EPA 1991).

7.4.3 Comparison of Maximum Concentration to Ecologically Based Screening Level

For the remaining chemicals, the third step in the ecological chemical screening process is to compare potential contaminants associated with the site with ecologically based screening levels (EBSLs) or EPA ecological soil screening levels. If the maximum concentration for a given chemical is greater than or equal to the most conservative EBSL or ecological soil screening level, the chemical is retained for further evaluation. The EBSLs used for the screening are consistent with the INL Site-wide screening levels that are presented in Table A-6 in (INEEL 2004). Details for EBSL development and EBSL values are documented in Appendix D2 of the *Work Plan for Waste Area Groups 6 and 10 Operable Unit 10-04 Comprehensive Remedial Investigation/Feasibility Study* (DOE-ID 1999b).

7.5 Results of Ecological Risk Assessment Screening

This section summarizes the screening ERA results from exposure to radionuclides and nonradionuclides in soil from 0 to 10 ft at the tank farm. For consistency with the HHRA, calculations were made separately for the following sites:

- Soil Inside Tank Farm Boundary. This includes all sampling data for the seven sites with data that are located completely within the tank farm boundary: CPP-31, -27/33, -28, 79, -20/25, -26, and -32. These sites were evaluated together because of widespread surface soil mixing within the tank farm as a result of excavations that occurred after the spills or leaks at the individual sites. Sampling data in the top 0 to 10 ft of soil for all sites were combined and are summarized in Table I-6 of Appendix I. The maximum from all sites was initially screened against EBSLs. As shown in Table 7-15, chromium, Cs-137, and Sr-90 are the only COPCs to exceed screening levels.

- CPP-15 and CPP-58. These sites are located beyond the tank farm boundary. Both were evaluated using maximum COPC concentrations in the top 0 to 10 ft of soil. For CPP-15, maximum values for radionuclides were taken from Appendix I, Table I-4, and for nonradionuclides from Table I-5. For CPP-58, the maximums for radionuclides were taken from Table 7-7. Nonradionuclides were not analyzed at this site. As shown in Table 7-15, no COPCs were identified as a concern at CPP-58. However, at CPP-15, mercury exceeded initial screening levels.

Table 7-15. Initial screening for ecological risk to maximum concentration for CPP-15, CPP-58, and Soil Inside Tank Farm Boundary.

Detected Contaminant	Max Source Concentration (mg/kg or pCi/g)[a]	Background Concentration (mg/kg or pCi/g)	Max Concentration (> Background?)	Screening Value (mg/kg or pCi/g)	Max Concentration (> Screening Values?)
		CPP-58			
Am-241	9.91E-01	1.10E-02	Yes	1.78E+01	No
Cs-137	3.68E+01	8.20E-01	Yes	4.95E+03	No
Eu-154	5.99E-02	NA	NA	2.48E+03	No
Pu-238	2.68E-01	4.90E-03	Yes	1.78E+01	No
Pu-239	4.03E-02	1.00E-01	No	1.89E+01	No
Sr-90	3.30E+01	4.90E-01	Yes	3.34E+03	No
U-234	1.13E+00	1.44E+00	No	2.05E+01	No
U-235	6.79E-02	NA	NA	2.27E+01	No
		CPP-15			
Arsenic	1.43E+01	5.80E+00	Yes	1.80E+01	No
Chromium	2.83E+01	3.30E+01	No	1.00E+00	Yes
Mercury	5.31E-01	5.00E-02	**Yes**	3.00E-01	**Yes**
Nitrate	3.64E+00	NA	NA	1.84E+01	No
Zirconium	1.40E+01	NA	NA	3.23E+02	No
Am-241	8.00E-01	1.10E-02	Yes	1.78E+01	No
Co-60	2.20E-01	NA	NA	1.18E+03	No
Cs-137	9.00E+01	8.20E-01	Yes	4.95E+03	No

Table 7-15. (continued).

Detected Contaminant	Max Source Concentration (mg/kg or pCi/g)[a]	Background Concentration (mg/kg or pCi/g)	Max Concentration (> Background?)	Screening Value (mg/kg or pCi/g)	Max Concentration (> Screening Values?)
Eu-154	1.34E+00	NA	NA	2.48E+03	No
Np-237	2.24E-02	NA	NA	1.94E+01	No
Pu-238	3.30E-01	4.90E-03	Yes	1.78E+01	No
Pu-239	3.37E-02	1.00E-01	No	1.89E+01	No
Sr-90	2.67E+01	4.90E-01	Yes	3.34E+03	No
Tc-99	1.11E+01	NA	NA	1.60E+04	No
U-234	7.95E-01	1.44E+00	No	2.05E+01	No
U-235	4.00E-02	NA	NA	2.27E+01	No
U-238	7.50E-01	1.40E+00	No	2.32E+01	No
Soils Inside the Tank Farm Boundary					
Arsenic	1.24E+01	5.80E+00	Yes	1.80E+01	No
Chromium	6.03E+01	3.30E+01	**Yes**	1.00E+00	**Yes**
Fluoride	2.09E+00	NA	NA	2.69E+00	No
Manganese	2.38E+02	4.90E+02	No	1.05E+01	Yes
Mercury	3.00E-01	5.00E-02	Yes	3.00E-01	No
Nickel	1.94E+01	3.50E+01	No	3.00E+01	No
Nitrate	3.55E+00	NA	NA	1.84E+01	No
Am-241	8.71E+00	1.10E-02	Yes	1.78E+01	No
Co-60	6.13E+00	NA	NA	1.18E+03	No
Cs-137	5.10E+03	8.20E-01	Yes	4.95E+03	**Yes**
Eu-154	2.45E+02	NA	NA	2.48E+03	No
Np-137	1.10E-02	NA	NA	1.94E+01	No
Pu-238	5.85E+00	4.90E-03	Yes	1.78E+01	No
Pu-239	8.41E-01	1.00E-01	Yes	1.89E+01	No
Pu-239/240	3.40E-01	1.00E-01	Yes	1.89E+01	No
Pu-241	6.96E+00	NA	NA	3.73E+05	No
Sr-90	3.26E+04	4.90E-01	Yes	3.34E+03	**Yes**
Tc-99	1.61E+01	NA	NA	1.60E+04	No
U-233/234	1.81E+00	NA	NA	2.05E+01	No
U-234	1.70E+00	1.44E+00	Yes	2.05E+01	No
U-235	1.04E-01	NA	NA	2.27E+01	No
U-238	1.13E+00	1.40E+00	No	2.32E+01	No

Bolded “Yes” responses indicate COPCs that remain for further assessment after screening.
"NA" in Step 1 indicates that a background value is not available.
a. Radionuclides are decayed to 9/2004 (date of most recent sampling).
b. Maximum value for Cs-137 was decayed from 1992 sampling result (6,730 pCi/g).

7.6 Ecological Risk Assessment Results

Both CPP-15 and Soil Inside Tank Farm Boundary had contaminants at concentrations above screening levels. Hazard quotients and HIs were calculated for both nonradionuclides and radionuclides (both for external and internal exposure) using the approach documented in the OU 10-04 Comprehensive RI/FS (DOE-ID 2001). Changes based on the new or updated chemical-specific documents from EPA (EPA 2006e) were included for antimony, arsenic, barium, beryllium, cadmium, chromium (no value is available for exposure to plants), cobalt, lead, and vanadium. A hazard quotient is developed by dividing the maximum dose from the contaminant by its toxicity value. An HI is developed by summing hazard quotients for each contaminant by species. At the INL Site, it is accepted that, if the total HI does not exceed 10, then the contaminants remaining can be eliminated for risk to ecological receptors at the population level.

7.6.1 CPP-15

As is shown in Tables 7-16 and 7-17, none of the HIs exceeded 10 for any of the species evaluated. Therefore, CPP-15 should not pose a risk to ecological receptors.

7.6.2 Sites within Tank Farm Boundary

As shown in Tables 7-18 and 7-19, none of the HIs exceeded 1 for chromium. There appears to be a possibility of significant internal risk (with HIs over 400) from internal exposure to radionuclides at this site (see Tables 7-20 and 7-21); however, the external exposure appears to be at acceptable levels (the highest HI is 4.0) (see Tables 7-22 and 7-23).

Table 7-16. Dose for nonradionuclides at CPP-15 (using 6.50E-03 hectares for site size).

Concentrations	Mercury
Maximum Concentration	5.32E-01
Selected species and functional groups	Mercury
Great Basin spadefoot toad	2.14E-04
Mourning dove (AV122)	3.58E-05
Sage sparrow (AV222)	4.95E-04
Ferruginous hawk (AV322)	1.49E-07
Loggerhead shrike (AV322)	5.69E-05
Burrowing owl (AV322A)	1.08E-05
Black-billed magpie (AV422)	2.59E-05
Mule deer (M122)	1.06E-05
Pygmy rabbit (M122A)	5.11E-02
Townsend's western big-eared bat (M210A)	1.23E-04
Coyote (M322)	1.48E-08
Deer mouse (M422)	3.13E-02
Sagebrush lizard (R222)	1.12E-04
Plants	4.79E-01
Grasshoppers, beetles	NA

"NA"- no toxicity value is available.

Table 7-17. Hazard quotients for nonradionuclides at CPP-15 (using 6.50E-03 hectares for site size).

Concentrations	Mercury	
Maximum Concentration	5.32E-01	
	Hazard Quotient (unitless)	
Selected Species and functional groups	Mercury	Total HI
Great Basin spadefoot toad	NA	NA
Mourning dove (AV122)	9.E-03	9.E-03
Sage sparrow (AV222)	2.E-01	2.E-01
Ferruginous hawk (AV322)	5.E-05	5.E-05
Loggerhead shrike (AV322)	2.E-02	2.E-02
Burrowing owl (AV322A)	4.E-03	4.E-03
Black-billed magpie (AV422)	9.E-03	9.E-03
Mule deer (M122)	5.E-04	5.E-04
Pygmy rabbit (M122A)	3.E+00	3.E+00
Townsend's western big-eared bat (M210A)	6.E-03	6.E-03
Coyote (M322)	7.E-07	7.E-07
Deer mouse (M422)	8.E-01	8.E-01
Sagebrush lizard (R222)	NA	NA
Plants	2.E+00	2.E+00
Grasshoppers, beetles	NA	NA

NA = No toxicity value is available.

Table 7-18. Dose for nonradionuclides at Soil Inside Tank Farm Boundary (using 2.93 hectares for site size).

Concentrations	Chromium
Maximum Concentration	6.03E+01
Selected species and functional groups	Chromium
Great Basin spadefoot toad	4.60E-01
Mourning dove (AV122)	1.37E+00
Sage sparrow (AV222)	4.92E-01
Ferruginous hawk (AV322)	4.16E-01
Loggerhead shrike (AV322)	1.29E+00
Burrowing owl (AV322A)	3.23E-01
Black-billed magpie (AV422)	1.21E+00
Mule deer (M122)	2.38E-01
Pygmy rabbit (M122A)	1.22E+00
Townsend’s western big-eared bat (M210A)	7.72E-01
Coyote (M322)	4.77E-01
Deer mouse (M422)	1.86E+00
Sagebrush lizard (R222)	1.75E-02
Plants	1.15E+01
Grasshoppers, beetles	NA

NA = No toxicity value is available.

Table 7-19. Hazard quotients for nonradionuclides at Soil Inside Tank Farm Boundary (using 2.93 hectares for site size).

Concentrations	Chromium	
Maximum Concentration	6.03E+01	
Selected species and functional groups	Chromium	HI
Great Basin spadefoot toad	NA	NA
Mourning dove (AV122)	5.E-02	5.E-02
Sage sparrow (AV222)	2.E-02	2.E-02
Ferruginous hawk (AV322)	2.E-02	2.E-02
Loggerhead shrike (AV322)	5.E-02	5.E-02
Burrowing owl (AV322A)	1.E-02	1.E-02
Black-billed magpie	5.E-02	5.E-02
Mule deer (M122)	7.E-03	7.E-03
Pygmy rabbit (M122A)	4.E-02	4.E-02
Townsend's western big-eared bat (M210A)	2.E-02	2.E-02
Coyote (M322)	1.E-02	1.E-02
Deer mouse (M422)	5.E-02	5.E-02
Sagebrush lizard (R222)	NA	NA
Plants	NA	NA
Grasshoppers, beetles	NA	NA

Table 7-20. Dose for internal exposure of ecological receptors to radionuclides at Soil Inside Tank Farm Boundary.

Maximum Concentration (pCi/g)	5.10E+04	3.26E+04
Functional Groups	Cs-137	Sr-90
	Internal Dose (Gy/day)	
Great Basin spadefoot toad	9.40E-02	3.00E-01
Mourning dove	9.40E-02	3.00E-01
Sage sparrow	6.11E-02	1.95E-01
Ferruginous hawk	6.11E-02	1.95E-01
Loggerhead shrike	6.11E-02	1.95E-01
Burrowing owl	2.35E-02	7.50E-02
Black-billed magpie	9.40E-02	3.00E-01
Mule deer	9.40E-02	2.14E-01
Pygmy rabbit	9.40E-02	2.14E-01
Townsend's western big-eared bat	9.40E-02	2.14E-01
Coyote	9.40E-02	2.14E-01
Deer mouse	9.40E-02	2.14E-01
Sagebrush lizard	9.40E-02	3.00E-01
Plants	9.40E-02	3.00E-01
Grasshoppers, beetles	9.40E-02	3.70E+00

Table 7-21. Hazard quotients for internal exposure of ecological receptors to radionuclides at Soil Inside Tank Farm Boundary.

Maximum Concentration (pCi/g)	5.10E+04	3.26E+04	
Functional Groups	Cs-137	Sr-90	
	Hazard Quotient (unitless)		HI
Avian herbivores (AV121)	2.E+01	8.E+01	**1.E+02**[a]
Avian herbivores (AV122)	9.E+01	3.E+02	**4.E+02**
Avian insectivores (AV210)	6.E+01	2.E+02	**3.E+02**
Black tern	2.E+01	8.E+01	**1.E+02**
Avian insectivores (AV210A)	6.E+01	2.E+02	**3.E+02**
Avian insectivores (AV221)	6.E+01	2.E+02	**3.E+02**
Avian insectivores (AV222)	9.E+01	3.E+02	**4.E+02**
Avian insectivores (AV222A)	6.E+01	2.E+02	**3.E+02**
Great Basin spadefoot toad	9.E+01	3.E+02	**4.E+02**
Mourning dove	9.E+01	3.E+02	**4.E+02**
Sage sparrow	6.E+01	2.E+02	**3.E+02**
Ferruginous hawk	6.E+01	2.E+02	**3.E+02**
Loggerhead shrike	6.E+01	2.E+02	**3.E+02**
Burrowing owl	2.E+01	8.E+01	**1.E+02**
Black-billed magpie	9.E+01	3.E+02	**4.E+02**
Mule deer	9.E+01	2.E+02	**3.E+02**
Pygmy rabbit	9.E+01	2.E+02	**3.E+02**
Townsend's western big-eared bat	9.E+01	2.E+02	**3.E+02**
Coyote	9.E+01	2.E+02	**3.E+02**
Deer mouse	9.E+01	2.E+02	**3.E+02**
Sagebrush lizard	9.E+01	3.E+02	**4.E+02**
Plants	9.E+00	3.E+01	**4.E+01**
Grasshoppers, beetles	9.E+01	4.E+03	**4.E+03**

a. Bold indicates HI above 10.

Table 7-22. Dose for external exposure of ecological receptors to radionuclides at Soil Inside Tank Farm Boundary.

Maximum Concentration (pCi/g)	5.10E+04	3.26E+04
Functional Groups	Cs-137	Sr-90
	External Dose (Gy/day)	
Great Basin spadefoot toad	4.34E-03	0.00E+00
Mourning dove	2.17E-03	0.00E+00
Sage sparrow	0.00E+00	0.00E+00
Ferruginous hawk	0.00E+00	0.00E+00
Loggerhead shrike	0.00E+00	0.00E+00
Burrowing owl	0.00E+00	0.00E+00
Black-billed magpie	2.17E-03	0.00E+00
Mule deer	2.17E-03	0.00E+00
Pygmy rabbit	4.34E-03	0.00E+00
Townsend's western big-eared bat	2.17E-03	0.00E+00
Coyote	2.17E-03	0.00E+00
Deer mouse	4.34E-03	0.00E+00
Sagebrush lizard	2.17E-03	0.00E+00
Plants	2.17E-03	0.00E+00
Grasshoppers, beetles	2.17E-03	0.00E+00

Table 7-23. Hazard quotients for external exposure of ecological receptors to radionuclides at Soil Inside Tank Farm Boundary.

Maximum Concentration (pCi/g)	5.10E+04	3.26E+04	
Functional groups	Cs-137	Sr-90	
	Hazard Quotient (unitless)		HI
Great Basin spadefoot toad	4.E+00	0.E+00	4.E+00
Mourning dove	2.E+00	0.E+00	2.E+00
Sage sparrow	0.E+00	0.E+00	0.E+00
Ferruginous hawk	0.E+00	0.E+00	0.E+00
Loggerhead shrike	0.E+00	0.E+00	0.E+00
Burrowing owl	0.E+00	0.E+00	0.E+00
Black-billed magpie	2.E+00	0.E+00	2.E+00
Mule deer	2.E+00	0.E+00	2.E+00
Pygmy rabbit	4.E+00	0.E+00	4.E+00
Townsend's western big-eared bat	2.E+00	0.E+00	2.E+00
Coyote	2.E+00	0.E+00	2.E+00
Deer mouse	4.E+00	0.E+00	4.E+00
Sagebrush lizard	2.E+00	0.E+00	2.E+00
Plants	2.E-01	0.E+00	2.E-01
Grasshoppers, beetles	2.E+00	0.E+00	2.E+00

7.6.3 Summary of Results for the ERA

Maximum concentrations of nonradionuclides at CPP-15, CPP-58, and Soil Inside Tank Farm Boundary do not pose unacceptable risks to ecological receptors. Maximum concentrations of radionuclides are at acceptable levels for ecological receptors at CPP-15 and CPP-58. External exposure of ecological receptors to radionuclides is not a concern for Soil Inside the Tank Farm Boundary. However, internal exposure to radionuclides at this site could possibly impact ecological receptors (HIs over 400). This area was assessed as if it had freely available habitat for ecological receptors, and this is not the case. The surface of the tank farm is covered with gravel, asphalt, or structures. A more detailed assessment that takes these facts into account may result in a reduced calculated risk.

7.7 References

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8. GROUNDWATER RISK ASSESSMENT

Currently, Tc-99 and Sr-90 exceed drinking water standards in the Snake River Plain Aquifer (SRPA) beneath INTEC. The primary source of Tc-99 currently in the aquifer is the 1972 leak of sodium-bearing waste (SBW) at Site CPP-31. Sr-90 currently in the aquifer is a result of service waste discharges into the CPP-03 injection well. Although that well has been plugged and abandoned, Sr-90 discharges through that well are still arriving from the vadose zone as a result of backflow above the deep interbeds that occurred during periods of casing failure. The primary release of Sr-90 at land surface also occurred at Site CPP-31. In addition to these primary sources of contaminants, there were several incidental releases at sites investigated as part of the Operable Unit (OU) 3-13 remedial investigation/baseline risk assessment (RI/BRA), and at sites that were assigned to OU 3-14 for evaluation. The purpose of this section is to summarize the models used for evaluation, the predicted aquifer and vadose zone concentrations, and the resulting risk via ingestion of groundwater.

8.1 Overview of Conceptual Model and Predictive Results

To assess risks to hypothetical future residents potentially ingesting water from the SRPA that might receive contaminants from all sources combined, several numerical models were used to predict the spatio-temporal distribution of contaminants from all combined INTEC CERCLA sources. These models are discussed in their entirety in Appendixes A and J. Those presentations include a complete discussion of hydrogeochemical parameters, flow and chemical boundary conditions, contaminant source implementations, predictive results for the assessment of baseline concentrations, and an extensive sensitivity analysis. An overview of the conceptual models is presented below, followed by key results and a summary of the most sensitive parameters with associated uncertainty.

8.1.1 Overview of the Hydrogeologic System

The INTEC is constructed on relatively thick, gravelly, medium-to-coarse alluvial deposits. The alluvium ranges from 13 to 70 ft in thickness and rests on top of fractured basalt. Contaminants that have been released into the tank farm soils will be mobilized by dissolution and desorption by natural and anthropogenic water sources and will be transported out of the alluvial (surficial) sediments and into the vadose zone. Across INTEC, the alluvial materials have been largely disturbed by construction activities. These disturbances have removed most of the original geologic structure, while leaving material spanning the range of soil textures. This range results in spatially varying hydraulic and geochemical characteristics that have been quantified through a series of field investigations. Sufficient information has been obtained to determine the spatial distribution of hydraulic properties as quantified through geostatistical analysis. The amount and distribution of geochemical data were insufficient to analyze for spatial distribution, but available data provide a range of parameter values that is sufficient for bounding sensitivity analysis.

Underlying the surficial alluvium are a series of basalt flows and sedimentary interbeds. Water that infiltrates downward through the alluvium encounters zones of low-permeability interbed material, low-permeability basalt flows, and high-permeability basalt flows. The lower-permeability zones allow local accumulation of water that results in areas of high moisture content or saturation. In regions receiving sufficient recharge waters, perched water bodies form and persist as long as the recharge sources are present.

Ultimately, contaminants carried by recharge waters arrive at the vadose zone-aquifer interface that exists at roughly 460 ft below land surface. Once in the aquifer, the contaminants arriving from land surface are transported sub-horizontally by a combination of advection, dispersion, and adsorption which is dictated by the lithology of the aquifer. Lithology in the SRPA consists of interlayered basalt flows and

sedimentary interbeds which are much more continuous than they are in the vadose zone. The primary sedimentary interbed is the HI-interbed which separates the H and I basalt flows.

Flow in the SRPA generally occurs under unconfined conditions and is recharged through a combination of underflow originating from regional basins adjacent to the INL Site, regional groundwater flow, intermittent streams that terminate on the INL Site and from precipitation that infiltrates downward from land surface. Contaminants arriving at land surface are dispersed vertically as a result of the infiltration but are primarily transported horizontally. Contaminants introduced into the aquifer as a result of direct injection are distributed throughout the perforated depth of CPP-03 and are much more vertically extensive.

The primary driving force for contaminant transport from land surface occurs in the form of precipitation, in the form of recharge from the Big Lost River, and from anthropogenic water. Precipitation at the INL Site is highly transient and primarily occurs in the form of intermittent rain and spring snow melt. Recharge from the Big Lost River is associated with precipitation events and is influenced by regional drought cycles. Anthropogenic waters infiltrating at land surface occur throughout the INTEC area and historically have been focused in the former percolation ponds to the south of INTEC. Currently, the anthropogenic water losses are thought to be distributed more in northern INTEC and are associated with infiltration from the sewage treatment facilities, fire water line discharges, and other unknown water leaks.

8.1.2 Overview of Simulation Approach

In order to account for the spatially variable contrasts in lithology, associated distribution in hydrogeology, and spatio-temporally variable sources of recharge, a transient 3-dimensional simulation approach was taken. Several different conceptual models were parameterized to represent key aspects of the hydrogeochemical system. The key deciding factors were proximity to the tank farm and the geochemistry of the CPP-31 site. These factors resulted in using different models to predict the flux from the alluvium into the vadose zone, a single vadose zone model, and a single aquifer model. These were all coupled through their boundary conditions, which allowed the flow of contaminants and water to pass through each model sequentially, and are briefly described below.

- Most of the contaminants released at land surface were associated with miscellaneous soil sites which could be grouped as being either within the tank farm or outside of the tank farm. Transport from the alluvium and through the vadose zone from sites outside of the tank farm was accomplished using a single vadose zone model encompassing the Big Lost River to the north and the former location of the percolation ponds to the south. It extends in the north-south direction approximately 300 m north of the northern INTEC fence line to 800 m south of the former percolation ponds, as shown in Figure 8-1. The east-west model domain extends from approximately 200 m west of Lincoln Boulevard to 400 m east of the INTEC steam generating plant. A relatively coarse 20 × 30 grid (100 × 100 m) was used to encompass the primary INTEC recharge sources (i.e., the Big Lost River and former percolation ponds) while resulting in a computationally tractable model and is represented by the course grid in Figure 8-1. The vertical model domain extended from land surface to the SRPA and was gridded using a 1-m discretization in the alluvium and a 2-m discretization throughout the remainder of the vadose zone as illustrated in Figure 8-2.

  An atmospheric pressure boundary condition was applied to the gaseous phase at land surface (steady-state) and transient and spatially varying water fluxes were applied to represent recharge from natural and anthropogenic sources. Infiltration from the Big Lost River and precipitation comprise the natural water sources and infiltration from landscape irrigation, steam vent discharge,

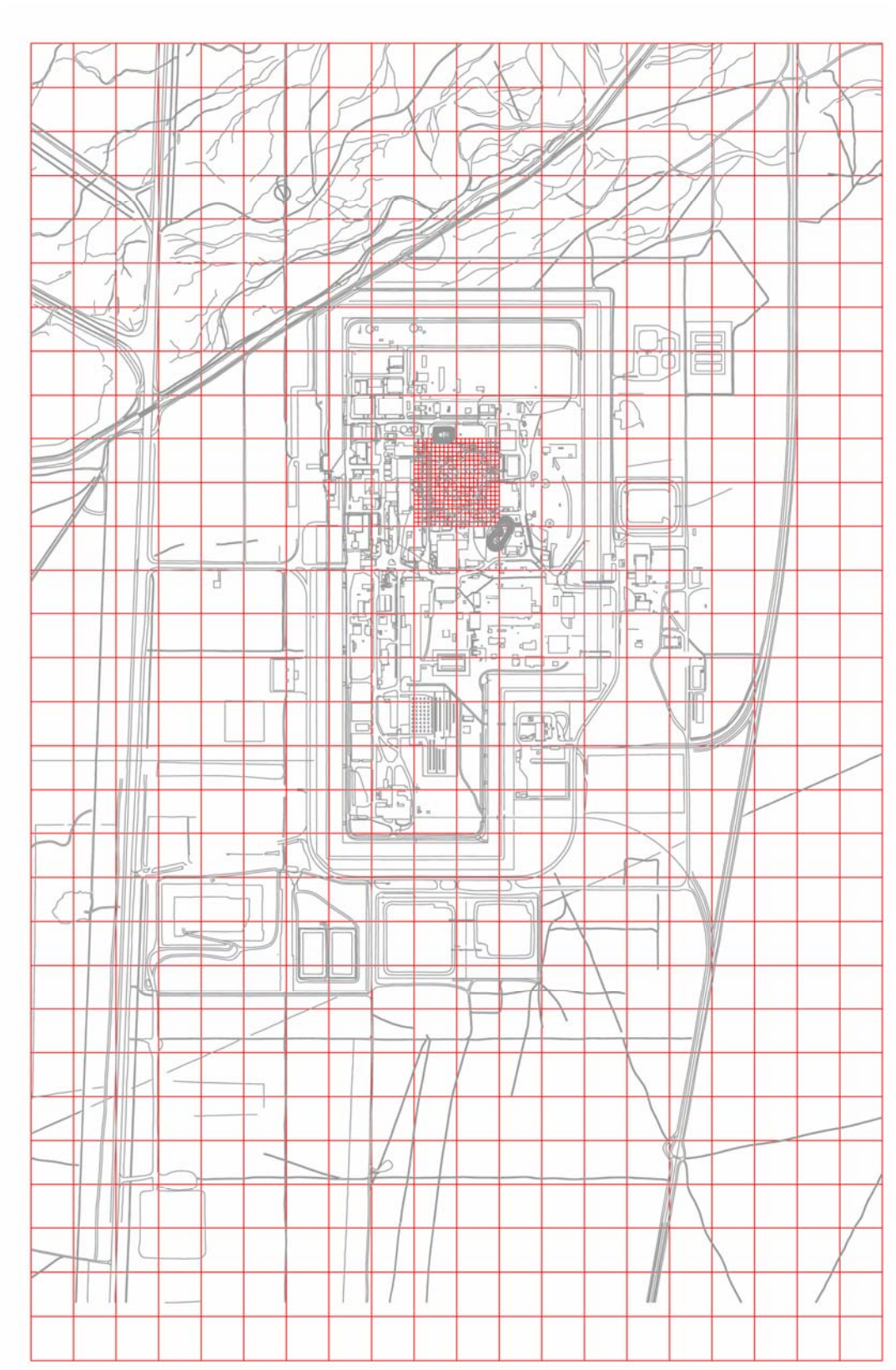

Figure 8-1. Vadose zone model horizontal discretization.

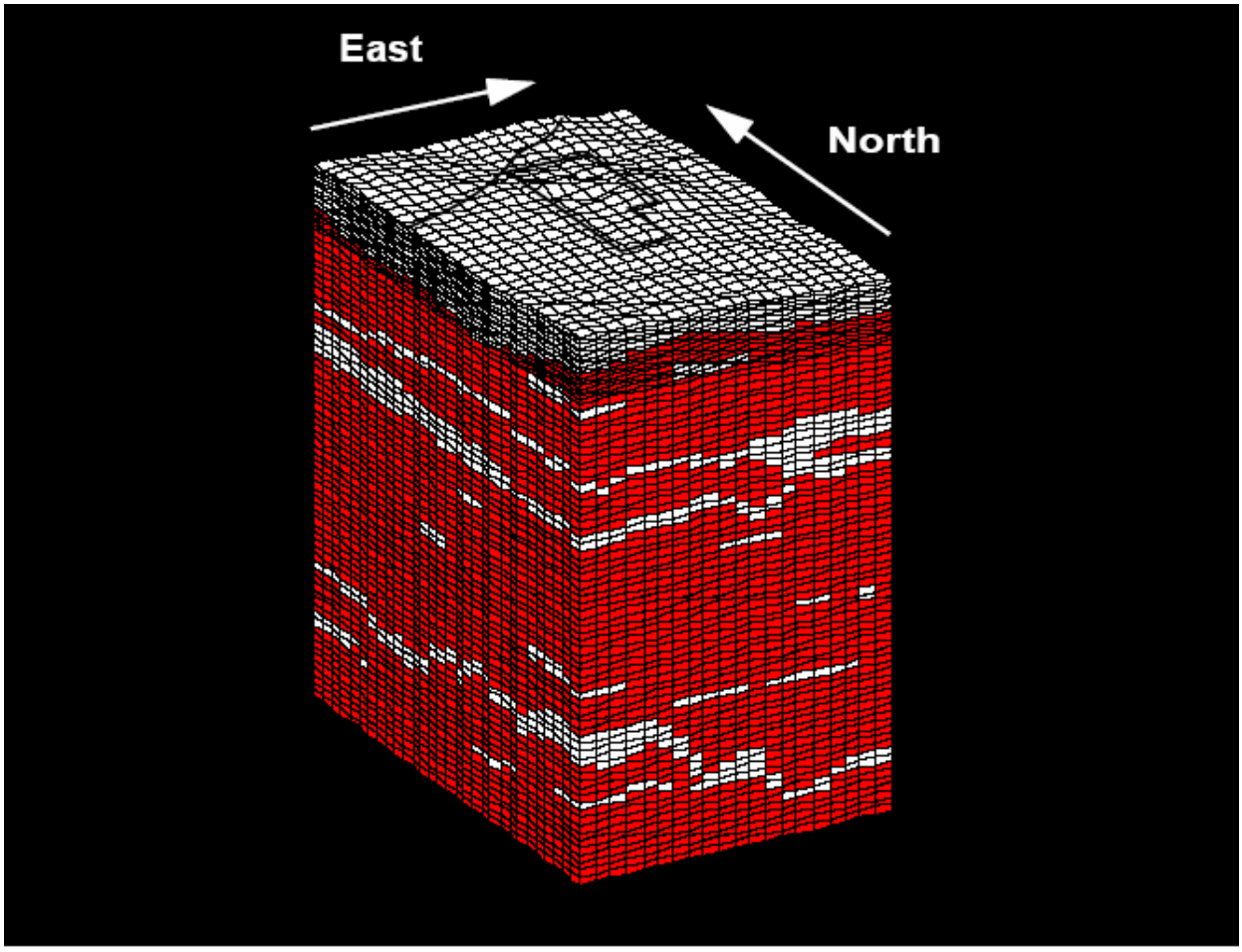

Figure 8-2. Vadose zone model vertical discretization with 35× vertical exaggeration.

sewage treatment lagoons, water system leaks, and the service waste ponds comprises the anthropogenic water sources. Infiltration resulting from precipitation is the largest single water source within the tank farm area and was estimated to be 18 cm/year from soil moisture monitoring and modeling (see Appendix B). The model also included the CPP-3 production well source within the interior domain. Lateral boundary conditions were no flow and the bottom boundary was assigned an atmospheric pressure to represent the water table for the aqueous phase.

Contaminant sources for sites outside of the tank farm were represented by their corresponding water sources, release timing, and activities.

- Site CPP-31 was a result of a failed valve box in which 18,600 gal of SBW were discharged near land surface. The unique geochemical nature of the release of SBW at CPP-31 (e.g., high sodium and nitrate content, low pH, and rapidly evolving geochemical conditions) could not be adequately represented using a traditional transport (K_d) approach. Instead, a coupled hydrogeochemical model was used to simulate the evolving geochemistry as the acidic solution dissolved in situ calcite minerals, re-precipitated aluminum minerals, and transported the solution cations through the alluvium. The primary adsorption mechanism was determined to be competitive cation exchange onto in situ clays. Parameterization of ToughReact was based on an extensive literature review, comparison of this parameterization to available laboratory data, and inclusion of site-specific chemistry of the released fluid. This model was used to represent the transport of Sr-90 through

the alluvium down to the upper alluvium-basalt interface. Hydraulic parameters were assumed to be constant in this relatively small-scale model, but the predicted geochemical behavior of the Sr-90 indicated that a constant adsorption approach would not be valid. Instead, it was found that there was an initially rapid release of Sr-90 from the alluvium, followed by much slower traveling Sr-90 migrating behind the initially released fraction. This residual Sr-90 could be represented by an effective K_d approach.

Results of the hydrogeochemical model included a mass-flux or flux of Sr-90 activity leaving the alluvium for the first 20 years following the CPP-31 release, an estimate of the amount remaining in the alluvium at 20 years, and an estimate of the mobility (effective K_d) for the Sr-90 remaining in the alluvium. The activity flux for the first 20 years was put into the fine-scale grid (Figure 8-1) of the previously discussed vadose zone model at the alluvium-basalt interface. The resultant effective K_d and remaining Sr-90 activity were placed in the fine-scale model at an elevation mapped to the measured Sr-90 concentrations in the alluvium. Transport of the total Sr-90 through the remaining vadose zone was then conducted.

Transport of other contaminants released within the tank farm was also simulated using the fine-scale vadose zone model (Figure 8-1) but was assumed to not be affected by the geochemical processes dictating the transport of Sr-90. These remaining contaminants were assigned a constant K_d, and transport predictions were made using the base vadose zone model.

- The aquifer model domain extends from approximately 2.5 km north of the INTEC facility to the southern INL Site boundary in the north-to-south direction and approximately 5.5 km east of the INTEC facility to slightly east of the Radioactive Waste Management Complex (RWMC) facility in the east-to-west direction (Figure 8-3). Selection of the aquifer model grid was guided by the need to predict aquifer water quality resulting from INTEC contamination over the next several decades while including the 3-dimensional aspects of aquifer thickness. The model was discretized into 400- × 400-m grid blocks in the horizontal direction, as illustrated in Figure 8-4. Local horizontal refinement corresponding to the discretization level applied in the vadose zone model was used within the footprint of the INTEC with a 200- × 200-m transition grid surrounding the vadose zone footprint.

  Boundary conditions for the aquifer model were determined by water table elevations and by depth measurements in deep wells (see Appendix A, Section 5.2). The aquifer thickness varies between 32 m and 379 m, and the model reproduces that variation. Vertical discretization was chosen to represent the HI interbed, water table elevation, and high-gradient areas as illustrated in Figure 8-4.

  To accommodate variations in recharge fluxes, the upper boundary condition included (1) infiltration from the vadose zone model, (2) infiltration from the Big Lost River outside the vadose zone footprint area, and (3) infiltration from precipitation outside the vadose zone footprint area, (4) reinjection to the CPP-3 disposal well, (5) pumping from CPP-1 and CPP-2 service water production wells, (6) pumping from the CPP-4 and CPP-5 potable water sources, (7) pumping from the Test Reactor Area (TRA) (now Reactor Technology Complex) production well, (8) injection to the TRA disposal well and ponds, and (9) production in the CFA-1 and CFA-2 water supply wells.

  Lateral boundary conditions were steady-state specified pressure to represent underflow and it was assumed that the bottom boundary was no-flow.

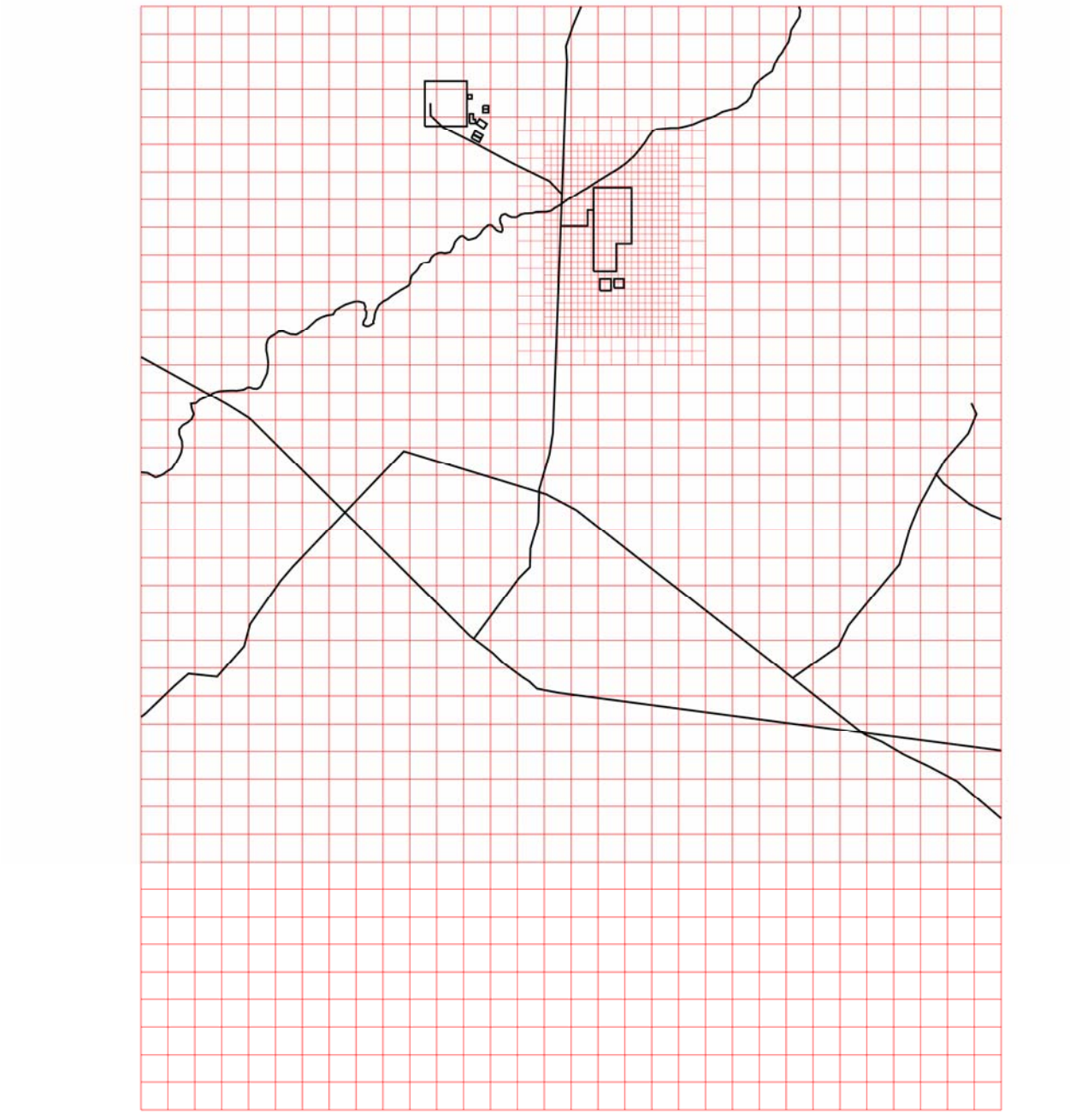

Figure 8-3. Aquifer model domain and horizontal discretization.

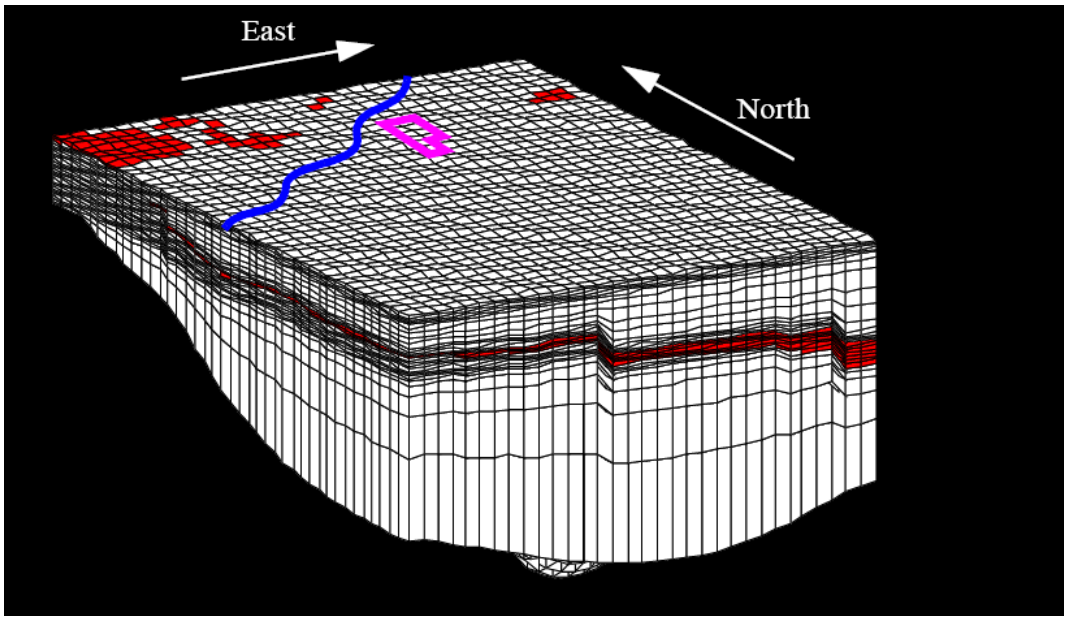

Figure 8-4. Aquifer model vertical discretization with 30× vertical exaggeration.

8.1.3 Overview of Model Parameterization

The spatial structure of the vadose zone sediments and basalts was represented in the vadose zone model by lithologic boundaries (tops and thicknesses of individual units) and through assignment of spatially variable hydraulic properties. Six material types were identified to represent high and low permeability for each of alluvium, interbed, and basalt. A combination of geostatistical analysis, kriging, indicator kriging, and geostatistical simulation was used to assign the spatial distribution of these six material types within the model domain from observations at well locations (summarized in Section 5.1.1 of Appendix A and presented in detail in Appendix C). Five of the resulting interbed units were fairly continuous, extending across most of the vadose zone domain as shown in Figure 8-5.

As part of the OU 3-13 Group 4 remedial activities (DOE-ID 2003), a total of 37 surficial alluvium and interbed samples were collected during Phase 1 drilling. Laboratory testing was performed to develop soil moisture characteristic curves and to determine material particle size distribution, porosity, effective porosity, bulk density, and initial moisture content. These more recent data, along with the data used in the OU 3-13 RI/ BRA (DOE-ID 1997) investigation were used to provide initial estimates of the model hydraulic parameters before adjusting them to match the percolation pond drain out during model calibration.

Lithologic units within the aquifer were determined similarly, and the resultant H basalt, HI interbed, and I basalt units are illustrated in Figure 8-4. The simulated HI interbed is represented by red and basalt is depicted by white grid blocks in that figure. Hydraulic properties in the aquifer were assigned following a geostatistical analysis of measured field data.

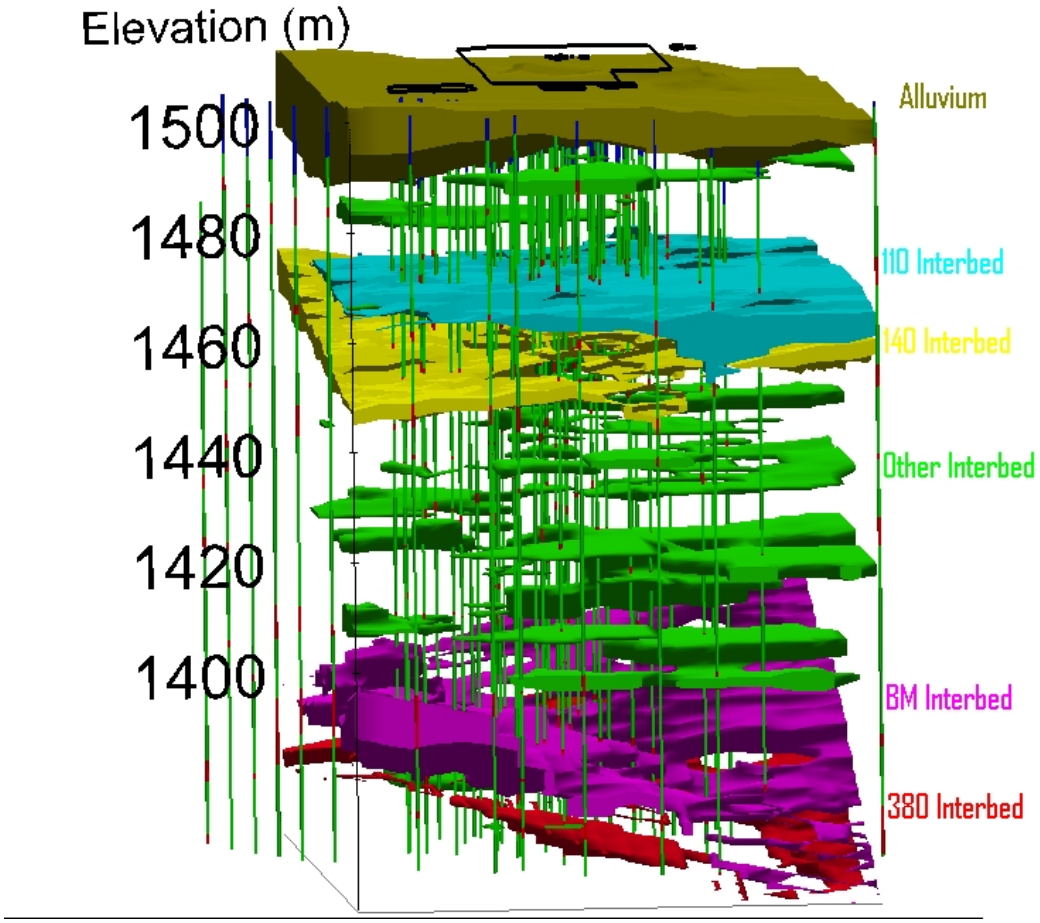

Figure 8-5. Predicted alluvium and interbed structure looking from the south.

8.1.4 Overview of Model Calibration

Throughout the vadose zone, measurements of perched water have been recorded. Variations in perched water elevations occur as a result of relocating the former percolation ponds (in 2002) and with reduced flows in the Big Lost River associated with the current hydrologic drought, which began in 1997. These transients provided a sufficient decline in some perched water bodies and were used in conjunction with the absence of perched water in other wells as calibration targets. Calibration of the vadose zone flow model to perched water levels can be found in Section 7.2 of Appendix A.

Calibration of the vadose zone transport model was to the arrival and concentration of contaminants in the perched water and aquifer resulting from the tank farm soil contamination. Four contaminants were identified as having reasonably accurate source terms and sufficient observational data for use in the calibration exercise (Tc-99, Sr-90, H-3, and I-129). More emphasis was placed on matching Tc-99 and Sr-90 concentrations because both contaminants had large or comparable tank farm sources relative to that from service waste. Less emphasis was placed on matching the H-3 and I-129 because these contaminants are mobile, and their arrival from the tank farm in the deep perched water could not be differentiated from that originating from the injection well failure. Calibration of the vadose zone transport model is presented in Section 7.3 of Appendix A.

As with the vadose zone model, flow and transport in the aquifer were calibrated separately. Flow was calibrated to the summer 2004 potentiometric surface and was achieved by adjusting the steady-state

Dirichlet boundary conditions and by globally adjusting the permeability in the H basalt, HI interbed, and I basalt units as discussed in Section 8.2 of Appendix A.

Calibration parameters for transport included porosity, dispersivity, and adsorption coefficients, which were adjusted to match the timing and concentration of contaminant arrival in aquifer wells resulting from the discharges into the CPP-3 injection well, into former percolation ponds, and from tank farm soil sites. Primary targets for calibration included H-3, Tc-99, and Sr-90 with more emphasis placed on matching those contaminants with more complete disposal records and with better concentration-time histories in downgradient wells. Of these calibration targets, tritium had originated primarily from service waste discharges that were regularly monitored. It was also the most frequently monitored contaminant in most aquifer wells. Matching concentrations immediately under the INTEC while also matching the concentrations far downgradient near the Central Facilities Area (CFA) required using a spatially varying dispersivity as discussed in Section 8.3 of Appendix A.

8.1.5 Identification of Contaminants of Concern

An extensive screening of contaminants was performed in the OU 3-13 RI/BRA (DOE-ID 1997) to determine contaminants of potential concern (COPCs). The OU 3-13 COPC list was used as the starting point for the OU 3-14 screening process. The list was reviewed using process knowledge, using new data collected since the OU 3-13 RI/BRA, and by incorporating stakeholder concerns. The computer code, GWSCREEN, was used to reduce the list of COPCs by removing those predicted to result in a dose or concentration less than 1/10 of the drinking water standard. The list of COPCs, their radioactive progeny, and the results of the GWSCREEN analysis are included in Table 9-2 of Appendix A of this document. COPCs that were not carried forward for further analysis include Am-241, C-14, Co-60, Cs-137, Pu-236, Pu-238, Pu-241, Pu-242, Pu-244, U-232, U-233, U-235, U-236, U-238, Cr, and As.

Ten COPCs, H-3, I-129, Np-237, Pu-239, Pu-240, Sr-90, Tc-99, U-234, Hg, and nitrate, were retained and transport through the alluvium, vadose zone, and aquifer were predicted using the full vadose zone and aquifer models previously described. By category, these sources include (1) the known liquid OU 3-14 releases, (2) the known liquid OU 3-13 releases (CPP-02, CPP-08, CPP-87/89 1975), (3) the OU 3-13 soil sources, (4) the CPP-3 injection well releases, and (5) the former percolation pond releases, which are summarized in Table 8-1.

Table 8-1. COPC source term summary.

COPC	OU 3-14 Releases (Ci or kg)	Injection Well (Ci or kg)	Former Percolation Ponds (Ci or kg)	OU 3-13 Soil Sites (Ci or kg)	OU 3-13 Liquid Releases (Ci)	Total (Ci or kg)
H-3	9.71E+0	2.01E+4	9.99E+2	0	3.78E+2	2.15E+4
I-129	1.26E-3	8.6E-1	8.2E-2	0	0	9.82E-1
Np-237	2.72E-2	1.07E+0	0	1.33E-1	0	1.23E+0
Pu-239	6.94E+0	1.35E-2	1.14E-3	1.05E+0	0	8.01E+0
Pu-240	1.07E+0	6.77E-3	5.71E-4	1.18E-1	0	1.19E+0
Sr-90	1.81E+4	2.43E+1	2.95E-1	9.18E+2	3.09E+2	1.94E+4
Tc-99	3.56E+0	1.19E+1	1.13E+0	9.30E-2	0	1.67E+1
U-234	1.38E-1	1.35E-1	4.03E-2	1.40E-1	0	4.10E-1
Mercury	7.24E+1	4.00E+2	0	5.85E+2	0	1.06E+3
Nitrate	2.12E+4	2.83E+6	1.31E+6	0	0	4.16E+6

8.1.6 Key Results

Table 8-2 contains the simulated peak concentrations in the vadose zone model through the year 2095 and includes the maximum contaminant level (MCL), which is applicable for the SRPA, year of the peak vadose zone concentration, peak vadose zone concentration, peak vadose zone concentration in 2005, peak vadose zone concentration in 2095, and the year the peak concentration falls below the MCL. Predicted concentrations for all of the COPCs in the vadose zone, except U-234, exceeded their respective MCL (applicable only for the SRPA), at some time during the simulations. Only tritium and U-234 were below their MCL in the vadose zone before the year 2095.

Table 8-3 contains the simulated peak concentrations in the aquifer model through the year 2095 and includes the MCL, year of the peak concentration, peak concentration, maximum concentration in 2005, peak simulated concentration in 2095, and the year concentrations fell below the MCL.

Seven of the 10 COPCs are predicted to exceed the MCL in the SRPA during the simulation period. However, only Sr-90 is predicted to exceed the MCL in the SRPA in the year 2095 or beyond. The contaminants that are predicted to exceed the MCL in the SRPA include tritium, I-129, Np-237, Sr-90, Tc-99, mercury, and nitrate. Tc-99 was predicted to exceed the MCL in the SRPA only briefly in 1999. However, it currently exceeds the MCL in two SRPA wells beneath INTEC. Plume maps of the COPCs that exceed the MCL currently, or exceed the MCL in model simulations, are presented in Figures 8-6 through 8-15. The contaminant concentrations were obtained through simulation in three dimensions. To present the concentration in a two-dimensional plume map, these data were reduced by

Table 8-2. Vadose zone simulation results.

COPC	SRPA MCL (pCi/L)	Year of Simulated Vadose Zone Peak	Peak Simulated Vadose Zone Concentration (pCi/L)	Peak Simulated Vadose Zone Concentration in 2005 (pCi/L)	Peak Simulated Vadose Zone Concentration in 2095 (pCi/L)	Year Below MCL
Carcinogens						
H-3	20,000	1965	1.82E+6	3.13E+4	1.82E+2	2011
I-129	1	1971	3.00E+1	9.86E+0	3.37E+0	>2095[a]
Np-237	15	1990	6.00E+3	1.01E+3	2.88E+2	>2300[a]
Pu-239	15	1973	5.38E+1	1.01E+2	9.12E+1	14226
Pu-240	15	1990	1.94E+1	1.91E+1	1.71E+1	2287
Sr-90	8	1978	1.99E+9	1.98E+7	4.24E+5	>2300[a]
Tc-99	900	1982	1.64E+5	1.91E+4	1.68E+3	>2095[a]
U-234	0.03 (mg/L)	1990	8.27E-4 (mg/L)	4.65E-4 (mg/L)	1.47E-4 (mg/L)	>2300[a]
Noncarcinogens						
Mercury	0.002 mg/L	1990	6.14E-1 (mg/L)	5.31E-1 (mg/L)	2.81E-1 (mg/L)	>4580[a]
Nitrate	10 mg/L	1981	6.76E+2 (mg/L)	1.61E+2 (mg/L)	4.14E+1 (mg/L)	>2095[a]

a. Concentration in vadose zone remained above MCL at simulation end time.

Table 8-3. Aquifer simulation results.

COPC	MCL (pCi/L)	Year of Simulated SRPA Peak	Peak Simulated SRPA Concentration (pCi/L)	Peak Simulated SRPA Concentration in 2005 (pCi/L)	Peak Simulated SRPA Concentration in 2095 (pCi/L)	Year Below MCL
Carcinogens						
H-3	20,000	1965	4.02E+6	9.97E+4	1.23E+2	2001
I-129	1	1970	2.26E+1	3.85E+0	9.00E-1	2080
Np-237	15	1965	2.71E+1	4.06E+0	4.22E+0	1987
Pu-239	15	1960	3.34E-1	1.72E-2	2.07E-3	Always
Pu-240	15	1960	1.67E-1	8.61E-3	1.03E-3	Always
Sr-90	8	1965	5.11E+3	4.08E+1	1.86E+1	2129
Tc-99	900	1999	9.35E+2	2.35E+2	9.84E+0	1999
U-234	0.03 (mg/L)	1958	5.36E-7 (mg/L)	1.15E-7 (mg/L)	2.34E-7 (mg/L)	Always
Noncarcinogens						
Mercury	0.002(mg/L)	1981	9.67E-3 (mg/L)	5.86E-4 (mg/L)	1.30E-4 (mg/L)	1993
Nitrate	10(mg/L)	1993	1.82E+1 (mg/L)	6.20E+0 (mg/L)	2.10E+0 (mg/L)	1998

using the maximum concentration at any depth at each horizontal grid block location for the horizontal contour plots. This data reduction scheme essentially compresses the contaminant plume in the vertical direction for the horizontal. The contour intervals are presented for each order of magnitude above and below the MCL, with the range spanning 0.01 × MCL to 10 × MCL. The concentration isopleths below, equal to, and above the MCL are denoted by thin dashed black lines, thin black line, a thick red line, and thin red lines, respectively. The nitrate plume concentration isopleths of 0.25, 0.5, 1, and × MCL are given instead because the SRPA background concentration is 0.15 × MCL. The peak aquifer concentration for all contaminants except Tc-99 and nitrate occurred during the CPP-3 injection well operation. The extent of the contamination resulting from the injection well is best illustrated in the year 1979 and this year is included in all plume maps. Additional plume maps for the aquifer near INTEC at peak concentration are provided for Tc-99 and nitrate. The contaminant source summary and period above the MCL for each COPC exceeding MCL are as follows:

- Tritium was predicted to exceed the MCL from 1954 through 2001 in the SRPA. The primary source of aquifer contamination was the CPP-3 injection well prior to 1984 and the service waste ponds after 1984. Radioactive decay, dispersion, and dilution reduce the simulated tritium concentrations below the MCL by 2006. The simulated tritium plume for the years 1979, 2005, 2049, and 2095 is presented in Figure 8-6. The model may be overpredicting measured SRPA tritium concentrations, which dropped below the MCL in the mid 1990s.

- I-129 was predicted to exceed the MCL from 1954 through 2080. The primary source of aquifer contamination was the CPP-3 injection well and the service waste ponds. Dispersion and dilution reduce the simulated I-129 concentrations below the SRPA MCL in the year 2080. Radioactive decay is negligible because the I-129 half-life is 1.57E+7 years. The simulated I-129 plume for the years 1979, 2005, 2049, and 2095 is presented in Figure 8-7. The model overpredicts I-129 concentrations because measured concentrations in the SRPA have been decreasing, and, since 2003, all wells have been below the MCL of 1 pCi/L.

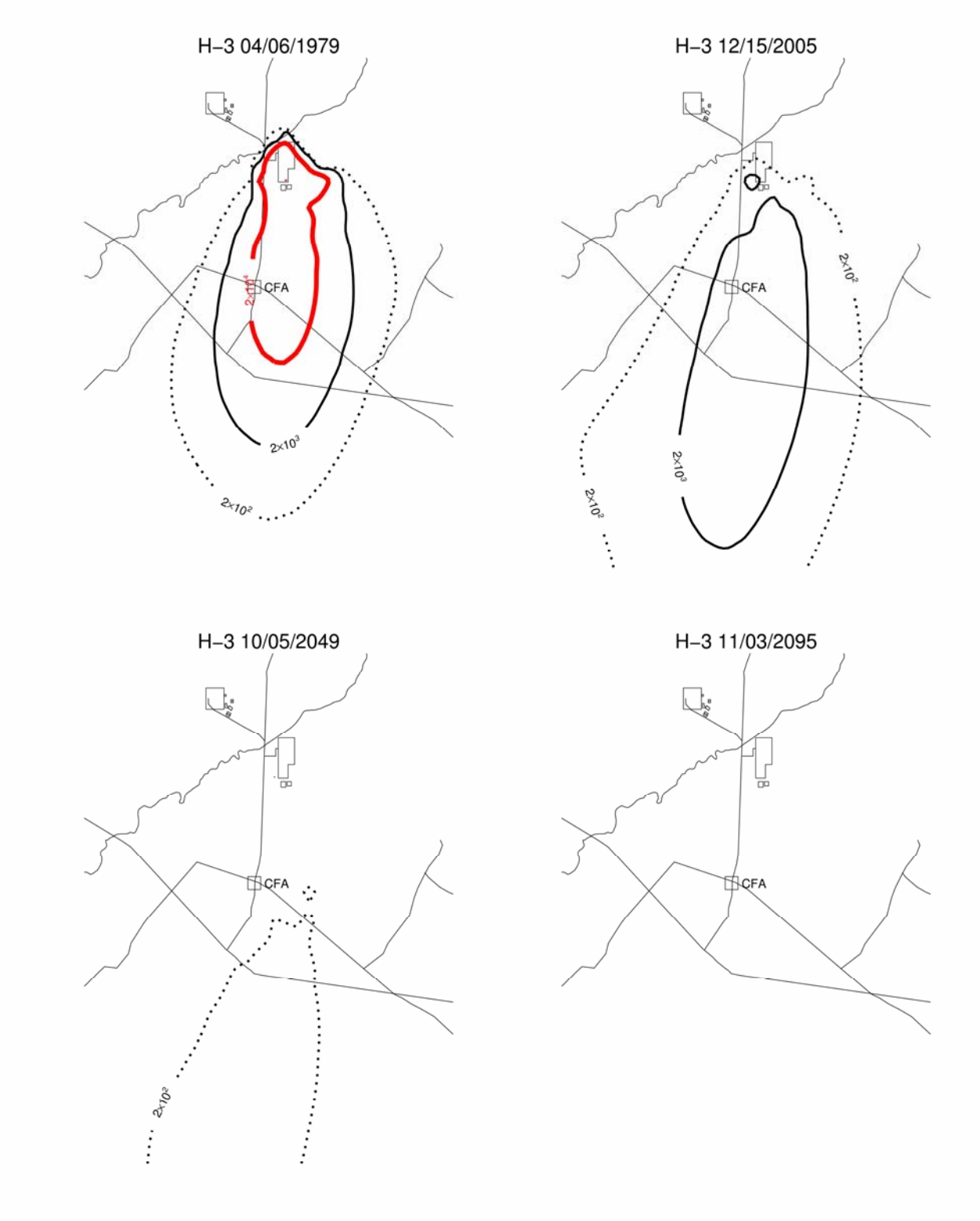

Figure 8-6. Predicted tritium plumes for the years 1979, 2005, 2049, and 2095.

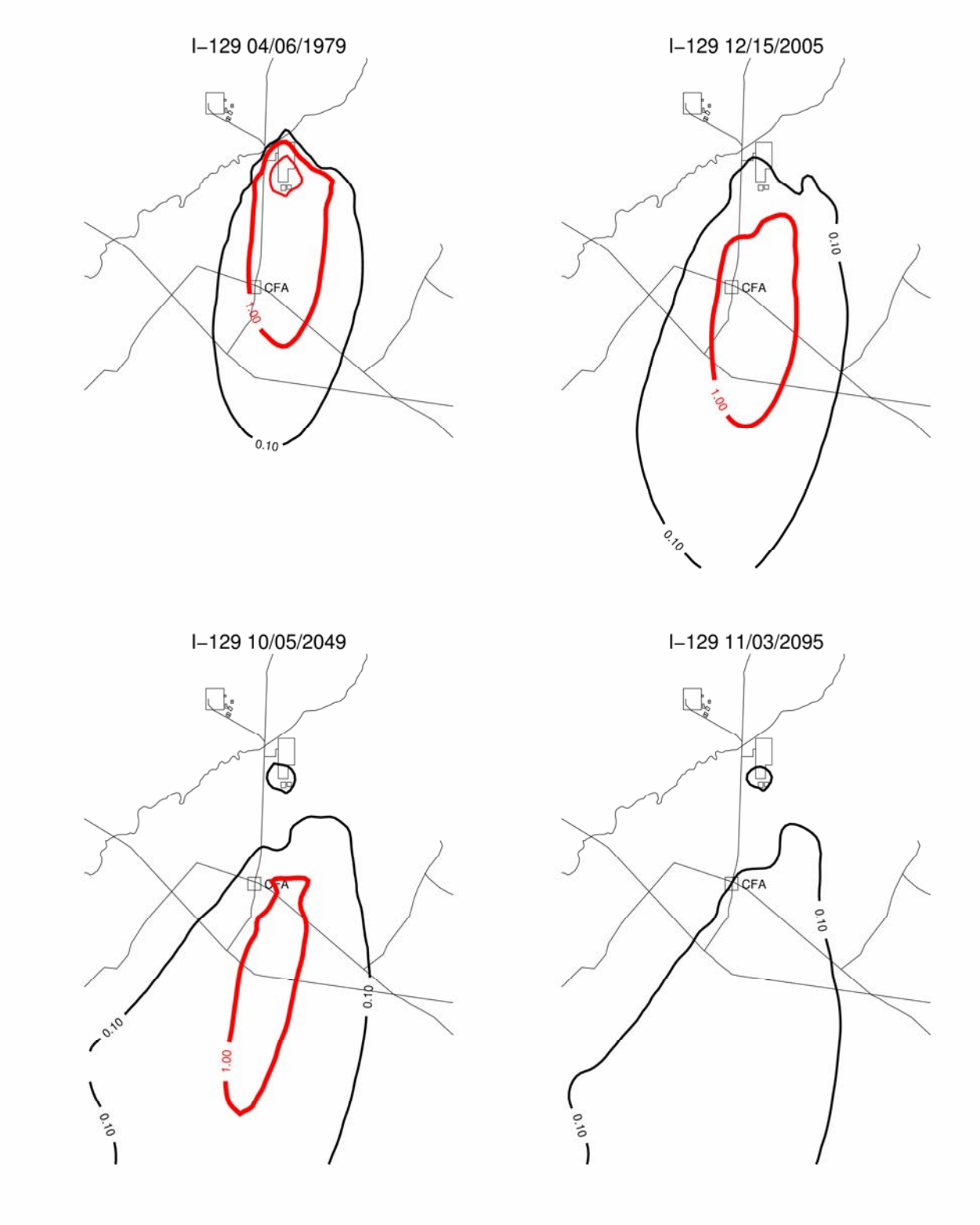

Figure 8-7. Predicted I-129 plumes for the years 1979, 2005, 2049, and 2095.

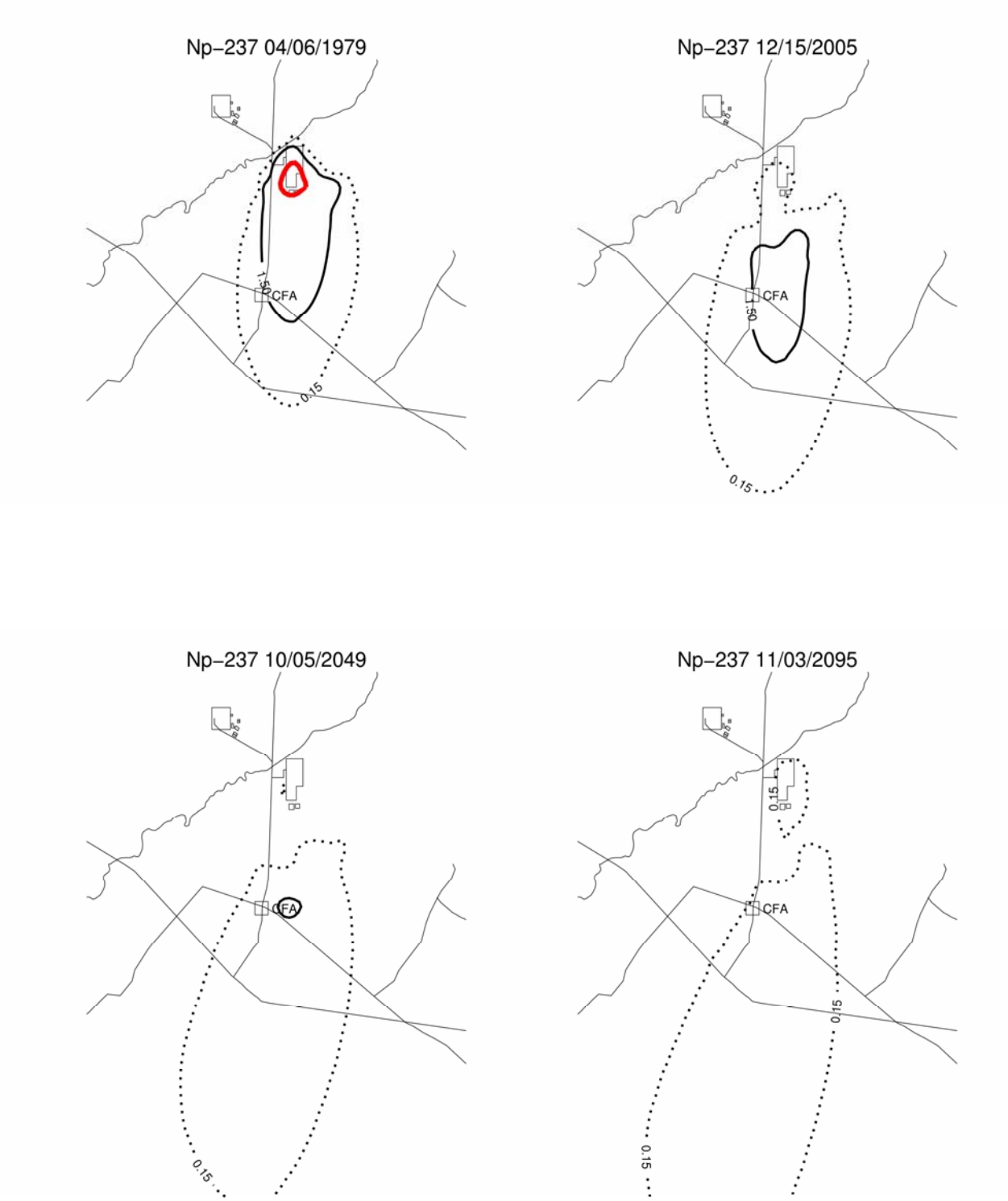

Figure 8-8. Predicted Np-237 plumes for the years 1979, 2005, 2049, and 2095.

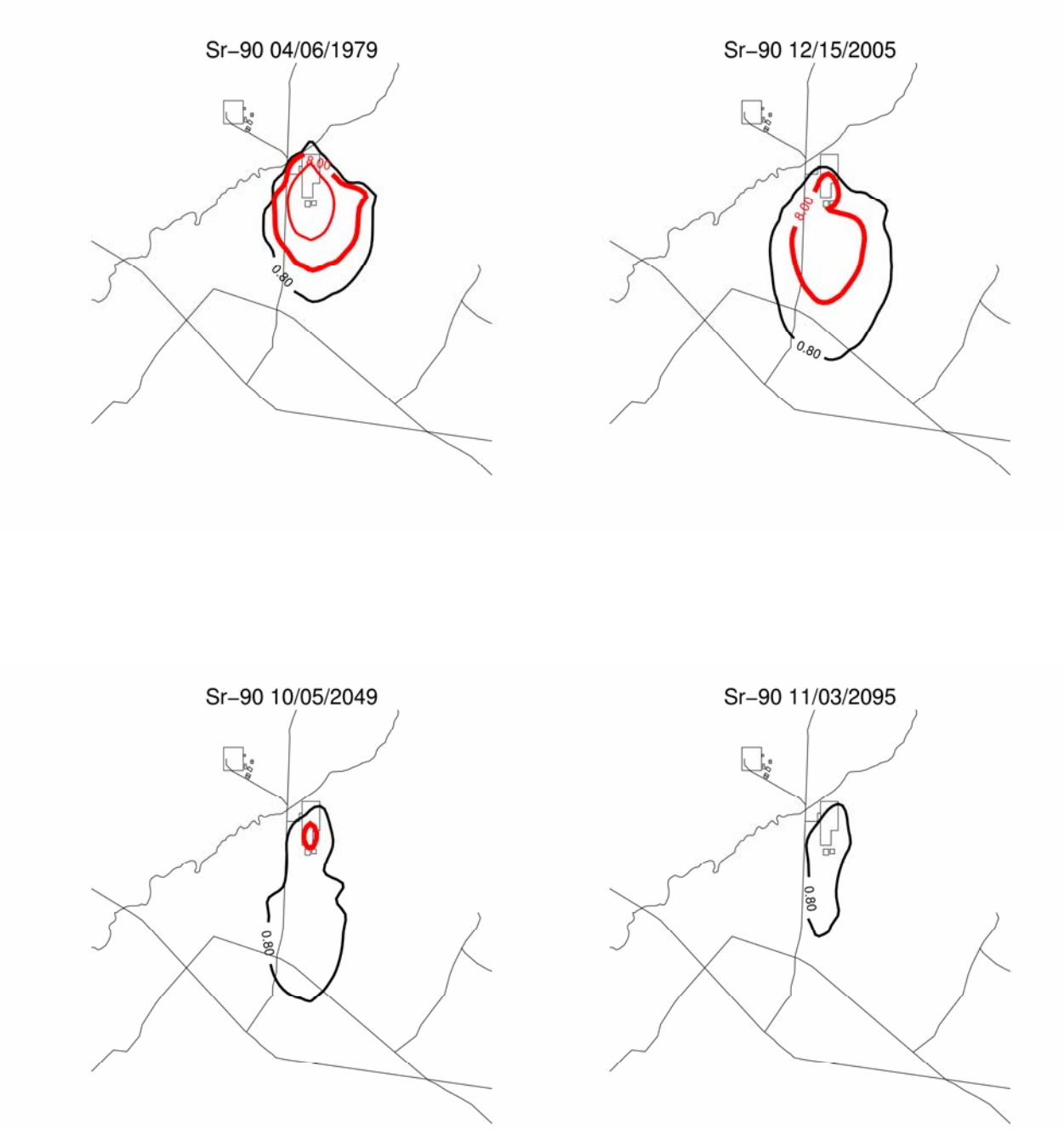

Figure 8-9. Predicted Sr-90 plumes for the years 1979, 2005, 2022, and 2096.

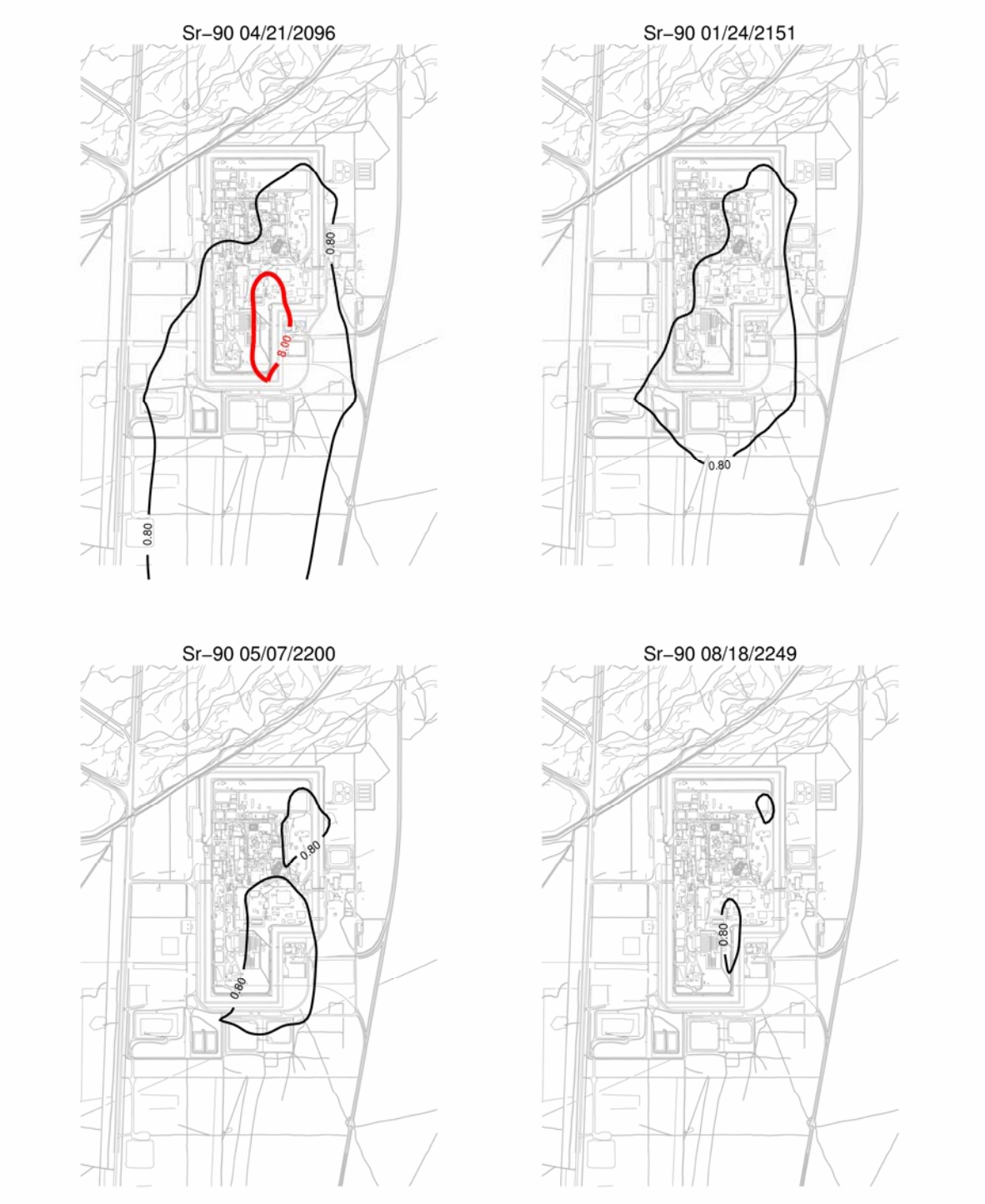

Figure 8-10. Predicted Sr-90 plumes for the years 2096, 2151, 2200, and 2249 near INTEC.

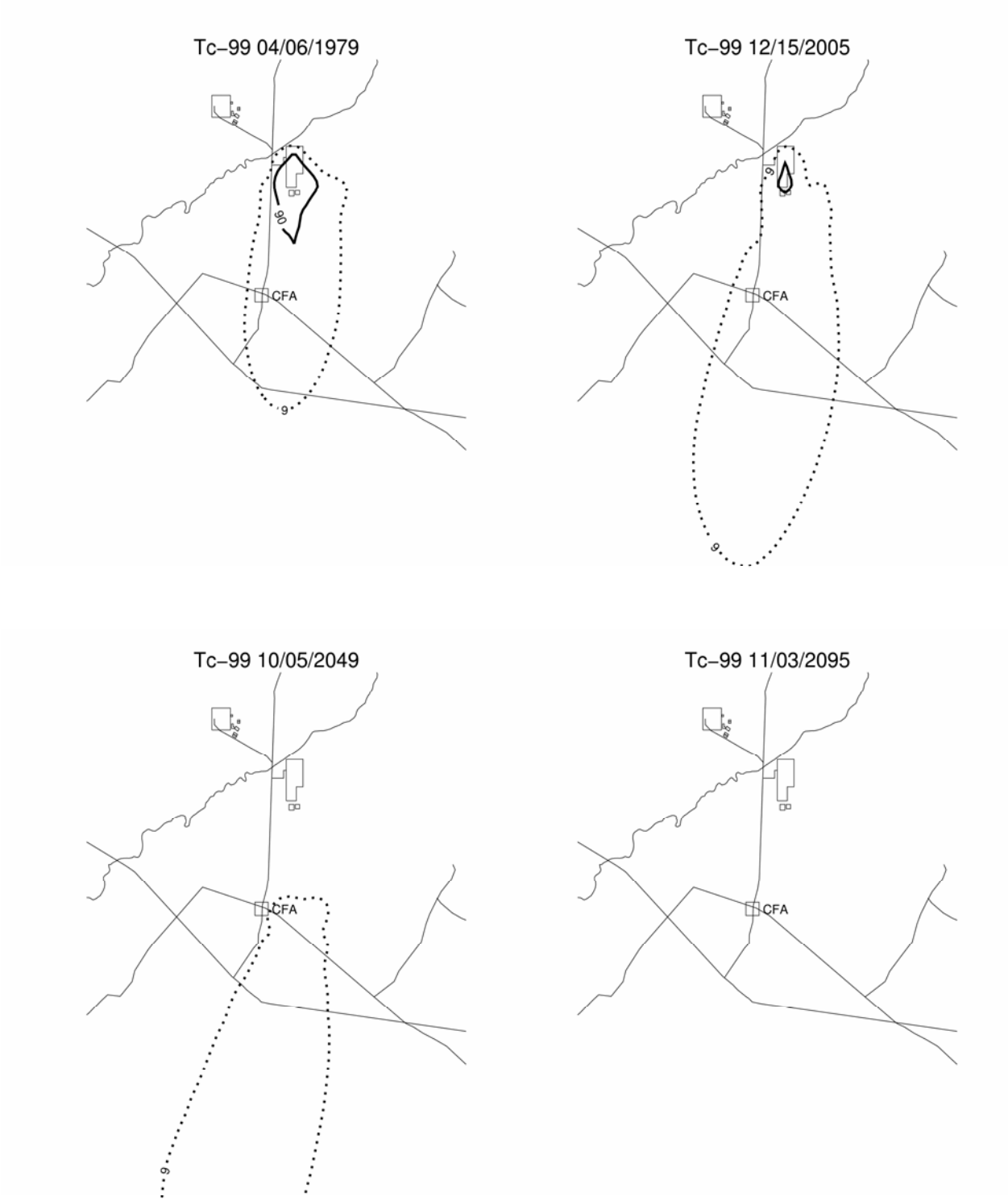

Figure 8-11. Predicted Tc-99 plumes for the years 1979, 2005, 2049, and 2095.

Figure 8-12. Predicted Tc-99 plumes at peak concentration in 1999.

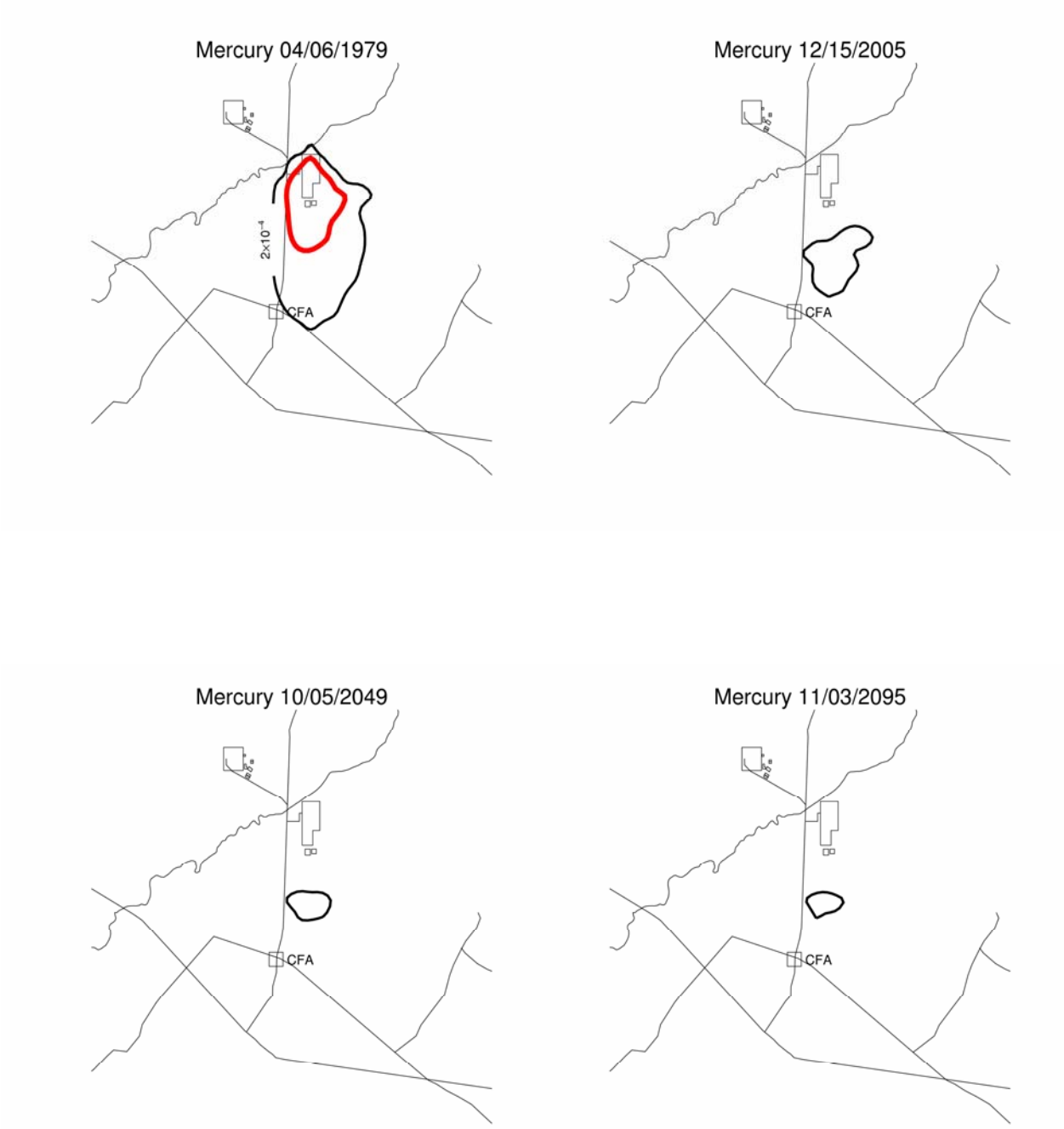

Figure 8-13. Predicted mercury plumes for the years 1979, 2005, 2049, and 2095.

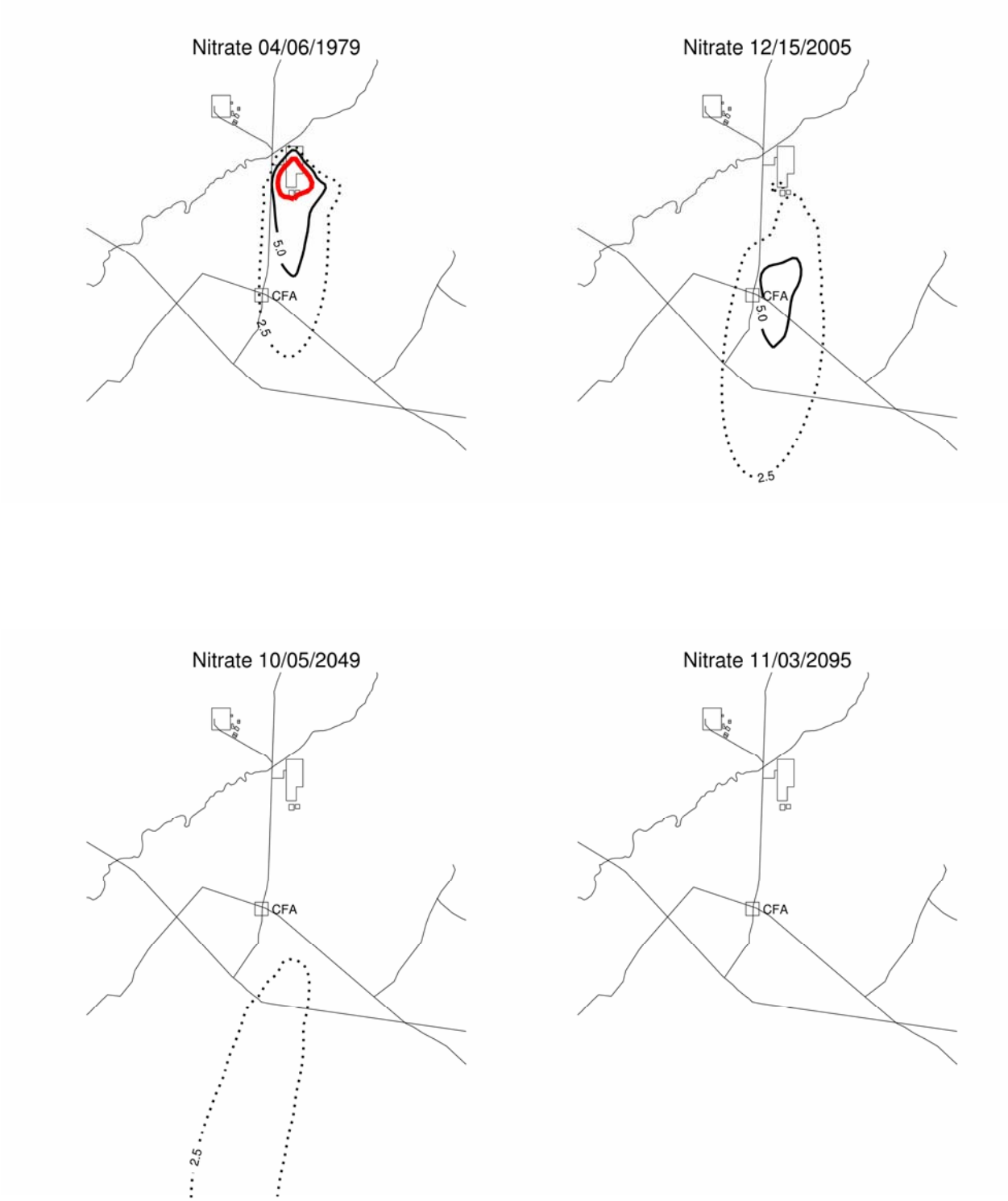

Figure 8-14. Predicted nitrate plumes for the years 1979, 2005, 2049, and 2095.

Figure 8-15. Predicted nitrate at peak concentration in 1993.

- Np-237 was predicted to exceed the MCL in the SRPA from 1954 through 1987. The primary source of aquifer contamination was the CPP-3 injection well. The simulated Np-237 plume in the SRPA for the years 1979, 2005, 2049, and 2095 is presented in Figure 8-8. All measured Np-237 concentrations are currently below the MCL in the SRPA.

- Sr-90 was predicted to exceed the MCL from 1958 through 2128. The Sr-90 concentrations in the aquifer were predicted to continually decline after 2015 but are not predicted to fall below the MCL until 2128. The simulations indicate that the Sr-90 from the tank farm, which is now in the perched water, may adversely impact the aquifer for a long period into the future. The simulated Sr-90 plume for the years 1979, 2005, 2022, and 2096 is presented in Figure 8-9. The simulated Sr-90 plume for 2096, 2151, 2200, and 2249 near INTEC is presented in Figure 8-10. The model overpredicts aquifer Sr-90 concentrations. The simulated Sr-90 maximum concentration in 2005 is about 2.5 times greater than the current measured maximum concentration.

- Tc-99 was predicted to only briefly exceed the MCL in 1999 following a period of Big Lost River flow. This is because the tank farm Tc-99 resides in the model deep in the vadose zone and is quickly moved to the aquifer when the Big Lost River flows. Current aquifer concentrations exceed the MCL in the TF-MON-230 well and are approximately an order of magnitude higher than the simulated current highest aquifer concentrations. The recently drilled ICPP-2021 well confirms that the TF-MON-230 well is not an anomaly, and a large area of the aquifer beneath INTEC could currently be above the MCL. This suggests the vadose zone model may be overestimating vadose zone attenuation or underestimating the vadose zone Tc-99 sources. The Tc-99 plume for the years 1986, 2005, 2049, and 2095 is presented in Figure 8-11. Figure 8-12 illustrates the Tc-99 plume at peak concentration in 1999 near INTEC.

- Mercury was predicted to exceed the MCL from 1954 through 1993. The primary source of aquifer contamination was the CPP-3 injection well. Dispersion and dilution in the model reduced aquifer concentrations below the MCL by the year 1994. The simulated mercury plume for the years 1979, 2005, 2049, and 2095 is presented in Figure 8-13.

- Nitrate was predicted to exceed the MCL from 1954 through 1998. The primary source of aquifer contamination was initially the CPP-3 injection well and later the service waste ponds. Dispersion and dilution in the model reduced aquifer concentrations below the MCL by the year 1998. The nitrate plume for the years 1979, 2005, 2049, and 2095 is presented in Figure 8-14. Figure 8-15 illustrates the nitrate plume at peak concentration in 1993 near INTEC. The model overpredicts nitrate concentrations because the measured nitrate concentrations are below MCLs in the SRPA.

In contrast to the OU 3-13 analysis, this OU 3-14 groundwater pathway analysis did not predict that the aquifer is at risk from plutonium. The difference occurs as a result of applying a chemically plausible K_d in the alluvium and interbed sediments (see Appendix D) and using isotope-specific half-lives. The OU 3-13 analysis was based on a very conservative Track 2 guidance K_d of 22 mL/g (DOE-ID 1994) and simulated the plutonium transport through the vadose zone as a single combined species conservatively using the longer Pu-241 half-life of 24,100 years. The combination of these two assumptions were overly conservative.

8.1.7 Assessment of Model Limitations

Model predictions are uncertain because models are simplified representations of complex systems. Deviations from reality occur as a result of simplification in model formulation and uncertainty in the model input parameters. These uncertainties were quantified and bounded through model calibration and

sensitivity analysis. In this work, a sensitivity analysis was performed and presented in Appendixes A and J to determine which input parameters model predictions were most sensitive to.

Five model parameters or design features were identified as having a potentially large impact on the transport of Tc-99. These were (1) the interbed structure and permeability, (2) assumed recharge from precipitation, (3) existence of fast flow paths allowing Tc-99 to reach the aquifer at the TF-MON-230 well, (4) the Tc-99 service waste source, and (5) the horizontal discretization used in the model were the focus of the sensitivity investigation presented in Appendix A. Observations of Tc-99 predicted behavior lead to the conclusions that

- The transport of Tc-99 is sensitive to the assumed historical infiltration rate through the tank farm. Its relative mobility allows the transport of Tc-99 to be influenced by the relative volumes of recharge from the Big Lost River and from land surface. Earlier arrival at depth resulting from higher infiltration rates is offset by peak flows in the Big Lost River. Also, because of its mobility, Tc-99 transport is not particularly sensitive to the spatial distribution of interbed material, its thickness, or its permeability. This is largely due to the fact that it moves as a conservative (nonreactive) species.

- It is likely that there is a hydraulic connection between the tank farm and the 380-ft interbed that allows Tc-99 to move rapidly into the aquifer near the TF MON-A 230 well. It is also likely that the capture zones of the CPP-1 and CPP-2 production wells are drawing Tc-99 already in the aquifer northward from the tank farm.

- Specified and numerical dispersion captured in the base grid adequately represents the physical dispersion occurring in the vadose zone. Reducing the grid block size has a corresponding decrease in numerical dispersion that results in overpredicting concentrations in wells near CPP-31 and in underpredicting concentrations further away. However, resultant peak concentrations in the aquifer were within an order of magnitude in either case.

The sensitivity of predicted strontium distributions to geochemical parameters in the alluvium and sedimentary interbeds and to hydraulic conditions throughout the vadose zone was investigated. The geochemical variables evaluated included parameters of the alluvium and interbeds (cation exchange capacity [CEC], Sr-90 selectivity, and K_d), and the geochemistry of the pore water (Na concentrations). These parameters determine (1) how much Sr-90 leaves the alluvium in the initial rapid release from CPP-31, (2) the mobility of the Sr-90 remaining in the alluvium, and (3) and the mobility of Sr-90 in the interbeds of the vadose zone. The following observations were made:

- The activity leaving the alluvium is a nearly exponential function of the CEC of alluvium. Plausible CEC values are in the 2-7 meq/100 g range. In this range, the activity leaving the alluvium is fairly sensitive and differs by roughly 6,000 Ci. However, within this CEC and release range, the resultant peak aquifer concentration only ranges between 18.5 and 11.5 pCi/L. As this activity was removed from the alluvium through the cation exchange process, the remaining 3,564-9,497 Ci were held in place through a pseudo-steadystate adsorption. Although more Sr-90 remains in the alluvium at higher CEC, it is essentially immobile with a K_d ranging between 2-17 mL/g. The combination of residual activity in the alluvium and K_d is sufficient to prevent the Sr-90 remaining in the alluvium from contributing significantly to aquifer contamination.

- Within the range of plausible sodium content and strontium selectivity coefficients, the amount of Sr-90 predicted to leave the alluvium falls within the range spanned by the plausible CEC range as does its effective K_d. As a result, the predicted concentrations in the aquifer would all be similar and would fall within the range predicted using a CEC of 2 and 7 meq/100 g.

- Sr-90 transport is extremely sensitive to the assumed adsorptive capacity of the interbeds. The range of K_d evaluated spanned the 22-mL/g to 78-mL/g range, resulting in peak concentrations of 110.8 pCi/L and 8.1 pCi/L, respectively. The K_d affects not only the CPP-31 release, but also every other land-surface source of Sr-90. Sr-90 originating from the OU 3-13 soil contamination, the failed injection well, or any of the OU 3-14 sources must pass through all of the interbeds in the vadose zone underlying INTEC. Because all of the sources are affected by adsorption in the interbeds, the K_d used to simulate transport through them is extremely important. Increasing the K_d partitions more of the aqueous phase Sr-90 onto the soils and decreases the aqueous phase concentrations; it also increases the travel time through the vadose zone and allows more radioactive decay to occur; decreasing the aqueous phase concentration decreases the concentration gradient and resultant dispersive transport. For example, the effective travel velocity is linearly proportional to the K_d: triple the K_d, triple the travel time. Additionally, the half-life of Sr-90 is roughly 28 years. If the travel time is tripled, and the time affected by peak aquifer concentrations is on the order of 200 years from now, that increases the residence time in the vadose zone to something like 600 years, or 20 half-lives.

There are no site-specific CEC measurements available for interbeds at INTEC. Based on available data from other sources, a range of interbed K_ds is expected, with this range spanning 20-80 mL/g. At the low end (22 mL/g), the resultant concentration is 110.8 pCi/L. At the high end, the resultant concentration is roughly 8 pCi/L. At the low end, the MCL is exceeded beyond year 2263, and at the high end it is exceeded through year 2096. For the midrange K_d of 50 mL/g used in the RI/BRA, the peak concentration is roughly 18.6 pCi/L and exceeds the MCL through 2129.

The sensitivity of Sr-90 transport to hydrologic parameters included examining the effect of infiltration rates through the tank farm, the spatial distribution of unaccounted for anthropogenic water, the land use scenario (which dictates the use of production wells), and the interbed dispersivity:

- Peak concentrations of 343 pCi/L were predicted when current estimates of the imbalance between pumped water and water discharges to the percolation ponds were focused near facilities in northern INTEC. This is on the order of 19 times the value predicted in the RI/BRA base case.

- Midrange peak aquifer concentrations resulted as the infiltration rate through the tank farm was varied and with the various land use scenarios. All of these variations are plausible.

- Very low peak aquifer concentrations resulted with increased dispersivity. The resultant match to perched water concentrations suggested that the dispersivity is not much higher than assumed in the RI/BRA base case.

The more sensitive performance measure was the time during which the MCL was predicted to be exceeded:

- With more anthropogenic water, the year was 2214, and, with anthropogenic water usage removed earlier, the date was closer to 2010.

- The 200-year difference is a combined result of faster transport through the vadose zone that occurs with higher fluxes; decreased residence time, allowing for less decay to occur; and increased dispersion that occurs in the aquifer in the absence of the production wells.

Of these, clearly, the largest influence is associated with uncertainty in the anthropogenic water discharges. The important performance measures for evaluating the end state of Sr-90 are peak

concentrations in 2095 and the time required for peak concentrations to be reduced below the MCL of 8 pCi/L. In all of the plausible parameters evaluated, we can conclude that

- The MCL will be exceeded in 2095 for all cases.
- The duration of elevated concentration is on the order of 100 years from now.
- The time frame is very sensitive to the interbed parameters.
- The extent to which the MCL is exceeded is very sensitive to water chemistry and infiltration from anthropogenic water sources.
- It is highly unlikely that the source of continued aquifer contamination will be from Sr-90 currently remaining in the alluvium.
- It is believed that the existing contamination in the perched water and sorbed to the interbed that poses the greatest future risk.

8.1.8 Uncertainty Analysis

Model prediction uncertainty is mainly the result of two things: (1) uncertainty in the conceptual model (i.e., complex processes oversimplified or not well understood) and (2) a lack of knowledge about the model parameter values. The conceptual model uncertainty can only be qualitatively assessed through comparing simulation results to observations and judging if there is sufficient complexity or understanding in the conceptual and numerical models to capture the observed behavior.

The model's parametric uncertainty was qualitatively assessed and the predictive simulations for each COPC were assigned a low, moderate, or high uncertainty based on the uncertainty analysis for each COPC.

- Tritium - The majority of the tritium released to the INTEC subsurface originated from the CPP-3 injection well. The injection well contributed 20,100 Ci and the OU 3-14 tank farm sources contributed only 10 Ci out of a total 21,500 Ci released to the subsurface. Uncertainty due to vadose zone model parameters, vadose zone model structure, net infiltration rate, and tank farm source terms is insignificant. The aquifer model was calibrated to tritium concentrations in monitoring wells, and tritium discharges into the service waste water were monitored regularly. The tritium concentrations in downgradient wells were also regularly monitored. The overall uncertainty in the tritium aquifer concentration prediction is low.
- I-129 - The majority of the I-129 released to the INTEC subsurface also originated from the CPP-3 injection well. The injection well contributed 0.86 Ci and the OU 3-14 tank farm sources contributed only 0.001 Ci out of a total 0.98 Ci released to the subsurface. Uncertainty due to vadose zone model parameters, vadose zone model structure, net infiltration rate, and tank farm source terms is insignificant. The aquifer model was not calibrated to aquifer I-129 concentrations but was compared to observed concentrations. The simulated and observed concentrations were similar, but the model overpredicts I-129 concentrations. I-129 discharges into the service waste stream and aquifer concentrations were monitored less frequently than tritium. The overall uncertainty in the I-129 predictions of groundwater concentration is low for sources originating from the injection well and the tank farm.

- Np-237 - The majority of the Np-237 released to the INTEC subsurface also originated from the CPP-3 injection well. The CPP-3 injection well contributed 1.07 Ci and the OU 3-14 tank farm sources contributed only 0.03 Ci out of a total 1.2 Ci released to the subsurface. Uncertainty due to vadose zone model parameters, vadose zone model structure, net infiltration rate, and tank farm source terms is small. Np-237 discharges to the service waste were monitored infrequently and were estimated using process knowledge. The overall uncertainty in groundwater concentration prediction from Np-237 is moderate because the injection well source was estimated.

- Pu-239 - The majority of the Pu-239 released into the INTEC subsurface originated from the OU 3-14 tank farm sources and the OU 3-13 soil contamination sites. The OU 3-14 sources contributed 6.9 Ci and the OU 3-13 soil contamination sites contributed 1.1 Ci out of 8.0 Ci released to the subsurface. The CPP-31 was the largest contributor to the Pu-239 inventory, which was estimated to be accurate within 30% (20% in liquid volume and 10% in activity concentration). Pu-239 is highly retarded in the subsurface and the travel time was estimated to be 90,000 years to the SRPA. The source uncertainty for Pu-239 is low, and the model prediction that the MCL will not be exceeded by 2095 has low uncertainty. However, the very long vadose zone travel time increases the predictive uncertainty, and the overall uncertainty in groundwater concentration prediction is high.

- Pu-240 - The majority of the Pu-240 released into the INTEC subsurface originated from the OU 3-14 tank farm sources and the OU 3-13 soil contamination sites. The OU 3-14 sources contributed 1.07 Ci and the OU 3-13 soil contamination sites contributed 0.12 Ci out of 1.2 Ci released to the subsurface. The Pu-240 source term uncertainty and vadose zone transport uncertainty are the same as that for Pu-239.

- Tc-99 - The majority of the Tc-99 released into the INTEC subsurface originated from the CPP-3 injection well, but the OU 3-14 tank farm source also contributed a significant fraction. The CPP-3 injection well contributed 11.9 Ci and the OU 3-14 tank farm source contributed 3.56 Ci out of 16.7 Ci released to the subsurface. The majority of the tank farm source is from the CPP-31 site and the source was estimated to be accurate within 30%. However, the CPP-3 injection well source was estimated from the aquifer concentration ratios of I-129 to Tc-99 and the I-129 source. The calibration of the vadose zone model to the observed Tc-99 concentrations in the northern shallow perched water wells is uncertain because data collection began well after the first arrival of Tc-99 and after the peak concentration would have occurred. The aquifer model also underpredicted the concentrations at the TF-MON-230 well. For these reasons, the uncertainty of the Tc-99 groundwater prediction is high.

- Sr-90 - The majority of the Sr-90 released into the INTEC subsurface originated in the tank farm from Sites CPP-31 and CPP-79 (deep). Estimates for activity released at these sites are accurate within 30%, but predictions of aquifer concentrations vary several orders of magnitude. The uncertainty is presented by a combination of the lack of site-specific interbed K_d values and by the unaccounted-for anthropogenic water being discharged in northern INTEC. Estimates of Sr-90 currently in the perched water are biased by an assumed K_d. For a given aqueous concentration, the vast majority of Sr-90 is on the soil surfaces. The higher the sorptive potential, the more the imbalance, and the more Sr-90 that can be contained in the perched water bodies and still match aquifer concentrations. Without site-specific interbed K_d values, this uncertainty cannot be resolved. Current efforts are underway to refine and control the anthropogenic water discharges at INTEC. These efforts will help resolve the discrepancies between pumped and discharged water volumes. Without this information, we must conclude that predictions of Sr-90 transport through the vadose zone are highly uncertain.

- U-234 - The OU 3-14 tank farm sources, OU 3-13 soil contamination sources, and the CPP-3 injection well all contributed similar amounts to the total U-234 released to the subsurface. The OU 3-14 tank farm sources contributed 0.095 Ci, the OU 3-13 soil contamination sources contributed 0.140 Ci, and the injection well contributed 0.135 Ci out of 0.391 Ci released to the subsurface. The majority of the tank farm source is from the CPP-31 site and the source was estimated to be accurate within 30%. The OU 3-13 soil site sources were estimated to be grossly conservative. The injection well U-234 was estimated from very limited data. U-234 is retarded in the subsurface, but the half-life is 244,000 years and radioactive decay en route to the aquifer is negligible. Thus, uncertainty in the radioactive decay attenuation en route to the aquifer is negligible. However, the source activity was probably overestimated given the grossly high values used by OU 3-13. The overall uncertainty of the U-234 groundwater concentration prediction is moderate because of the uncertainty in the injection well source term.

- Mercury - The majority of the mercury released into the subsurface originated from the OU 3-13 soil sources and CPP-3 injection well. The OU 3-13 soil sources contributed 585 kg and the injection well contributed 400 kg. The OU 3-14 tank farm sources only contributed 72 kg. The injection well source term was estimated and the OU 3-13 soil site source term was grossly overestimated and was equal to that used for the OU 3-13 RI/BRA. As a result, the overall uncertainty of the mercury groundwater concentration prediction is high. However, it is highly certain that the vadose zone sources will not exceed the MCL in the SRPA because the maximum predicted concentration after 2095 from the vadose zone sources is an order of magnitude below the MCL and the OU 3-13 sources were grossly overestimated.

- Nitrate - The majority of the nitrate released into the INTEC subsurface originated from the CPP-3 injection well and the former percolation ponds. The injection well contributed 2,830,000 kg, the former percolation ponds contributed 1,310,000 kg, and the OU 3-14 tank farm sources only contributed 21,200 kg out of a total 4,160,000 kg released into the subsurface. Uncertainty due to vadose zone model parameters, vadose zone model structure, net infiltration rate, and tank farm source terms is insignificant. The aquifer model was not calibrated to aquifer nitrate concentrations but was compared to observed concentrations. The simulated and observed concentrations were similar. The overall uncertainty in the nitrate groundwater concentration prediction is low.

8.1.9 Conclusions

Numerical models are a means of integrating all the site-specific data. They are most useful for understanding site characterization data, hypothesis testing, and evaluating remedial alternatives. They are less useful for making absolute predictions of future conditions. Models can be useful for designing field investigations by identifying the most useful data to collect and where to collect it. Other appropriate uses of numerical models are evaluation of conceptual model and data consistency. They should not be used as the only means to assess whether a contaminant of concern (COC) poses a risk to human health and the environment, but they can be used as corroborating evidence when included with the data.

Sr-90 was identified as the primary contaminant from the OU 3-14 tank farm releases that could adversely impact water quality beyond the year 2095. The simulation of the Site CPP-31 Sr-90 transport out of the alluvium did not use the constant K_d parameter approach. Instead, it was based on a complex geochemical model that considered the important processes that alter/control strontium transport as it was affected by the very high ionic strength of the acidic raffinate. The geochemical conceptual and numerical model is presented in Appendix J. The geochemical model simulation used to perform the BRA simulation used an alluvium CEC value of 7 and allowed approximately 12,336 Ci of undecayed Sr-90 to quickly leave the alluvium. The Sr-90 that was predicted to quickly leave the alluvium was decayed as it was input into the large-scale TETRAD vadose zone model. The alluvium K_d for the residual strontium

was also predicted by the geochemical model and was 2 mL/g. The model predicted that the Sr-90 most likely to have an adverse impact on water quality has already left the alluvium and is residing in the perched water. The Sr-90 currently residing in the alluvium may not impact aquifer water quality because the residual K_d is large enough to allow the remaining Sr-90 to decay before reaching the aquifer. Results of the OU 3-14 field investigation (see Section 5 in this OU 3-14 RI/BRA) suggest contaminated soil concentrations at the CPP-31 site are highest well above the alluvium/basalt interface, which is consistent with the K_d.

The OU 3-14 field investigation could not reliably estimate the volume of Sr-90-contaminated soil, because samples exist from only one vertical borehole. There is some evidence that the liquid from the CPP-31 leak moved horizontally and vertically along preferential flow paths and the single vertical borehole is not adequate to determine the mass of Sr-90 remaining in the alluvium.

Further characterizing the CPP-31 contamination site could reduce model uncertainty by allowing estimation of the total fraction of Sr-90 currently remaining in the alluvium. This characterization could be used to verify the model's predictions and to provide additional data for model calibration. However, characterization of the alluvium would require sufficient sampling to reliably estimate the Sr-90 contaminated soil volume. Due to operational constraints related to tank closures, it will not likely be possible to collect additional Sr-90 data in Site CPP-31 until after the OU 3-14 Record of Decision (ROD) is signed, which is planned for 2007. Furthermore, due to the expected heterogeneity of transport pathways in Site CPP-31 alluvium (horizontal and vertical infrastructure such as pipe in concrete trough and pilings and backfill under structures that could not be compacted), additional Sr-90 data might not significantly reduce the uncertainty for transport from the alluvium. Characterization of interbed properties for adsorption characteristics could be performed outside of the areas impacted by very high concentrations. There is the potential that this data could be collected using existing core and that it could be incorporated by OU 3-13 Group 4.

The aquifer concentration contribution from all sources of Sr-90, excluding the CPP-31 and CPP-79 (deep) sites, was 3.67 pCi/L in 2095 and is declining (see Appendix J, Section 8.0). The sources included all the OU 3-13 Group 3 soil sites, all the OU 3-14 sites except CPP-31 and CPP-79 (deep), and the CPP-3 injection well (OU 3-13, Site CPP-23). This implies the OU 3-13 soil sites alone will not pose an unacceptable risk to the aquifer.

8.2 Predicted Groundwater Risk

This section summarizes the BRA for a hypothetical future resident ingesting contaminated groundwater beneath INTEC.

The maximum simulated concentration anywhere in the aquifer in the year 2095 was used to identify the groundwater concentration and risk from groundwater consumption. The modeling methodology used to estimate groundwater contaminant concentrations is summarized below and is described in detail in Section 9 of Appendix A.

Potential human groundwater intakes of these contaminants were calculated using Equation (1) and standard default EPA exposure parameters for adult residential exposure:

$$\text{Intake}\ (\text{mg}/\text{kg}-\text{d}\ \text{or}\ \text{pCi}) = \frac{C_W \times IR \times EF \times ED \times FI}{BW \times AT} \quad (1)$$

where

C_W = peak contaminant concentration in groundwater (mg/L or pCi/L)

IR = intake rate (2 L/d)

EF = exposure frequency (350 d/yr)

ED = exposure duration (30 yr)

FI = fraction ingested from contaminant source (assume 1)

BW = body weight (70 kg) (only for nonradionuclides)

AT = averaging time (10,950 d for noncarcinogens; 25,550 d for nonradionuclide carcinogens).

The intake equation for radionuclides does not include the denominator (BW × AT) because radionuclides are evaluated using total (pCi) intake, rather than intake per body mass per day as done for chemicals. Carcinogenic risk from groundwater ingestion of radionuclides is calculated by multiplying the calculated intake by slope factors (SFs) from EPA's Health Effects Assessment Summary Tables (HEAST) - Radionuclides Table (EPA 2006a), formerly HEAST Table 4. The peak concentration, SFs, and risk for groundwater ingestion are listed in Table 8-4.

A noncarcinogenic hazard quotient (HQ) was calculated for mercury because this contaminant is not a carcinogen. The HQ (unitless) is the ratio of the intake (mg/kg-day) to an EPA reference dose (RfD) (mg/kg-day). The oral RfD for mercury was taken from the EPA Region 9 Preliminary Remediation Goals (PRG) Table (EPA 2006b). Nitrate, which is not a carcinogen and does not have an EPA RfD, is evaluated only by comparison to the MCL.

Table 8-4. Predicted groundwater risk and hazard index.

Carcinogens	MCL (pCi/L)	Maximum 2095 Concentration (pCi/L)	Slope Factor (1/pCi)	Risk
H-3	2.00E+4	1.2E+02	5.07E-14	1.31E-07
I-129	1.00E+0	9.0E-01	1.48E-10	2.80E-06
Np-237	1.50E+1	4.2E+00	6.18E-11	5.48E-06
Pu-239	1.50E+1	2.1E-03	1.35E-10	5.87E-09
Pu-240	1.50E+1	1.0E-03	1.35E-10	2.92E-09
Sr-90	8.00E+0	1.9E+01	5.59E-11	2.23E-05
Tc-99	9.00E+2	9.8E+00	2.75E-12	5.66E-07
U-234	1.87E+5[a]	1.5E+00	7.07E-11	2.17E-06
				Total = 3.3E-05

Table 8-4. (continued).

Carcinogens	MCL (pCi/L)	Maximum 2095 Concentration (pCi/L)	Slope Factor (1/pCi)	Risk
Noncarcinogens[b]	MCL (mg/L)	Maximum 2095 Concentration (mg/L)	Reference Dose (mg/kg-day)	Hazard Quotient (unitless)
Mercury	2.00E-3	1.3E-04	3.0E-04	0.01
Nitrate	1.00E+1	2.1E+00	1.6	0.04
				Total HI = 0.05

a. This is the activity equivalent to an MCL of 0.03 mg/L.
b. Noncarcinogens use reference dose (mg/kg-day) and hazard quotient in place of slope factor and risk, respectively.

8.3 References

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9. SUMMARY AND CONCLUSIONS

The Operable Unit (OU) 3-14 remedial investigation/baseline assessment (RI/BRA) is a focused investigation that built on information from the OU 3-13 Comprehensive Remedial Investigation/ Feasibility Study (RI/FS) for INTEC (DOE-ID 1997) and fills specific data gaps that had prevented the selection of final remedies for the tank farm soil and INTEC groundwater. This section summarizes the OU 3-14 RI/BRA. The RI/BRA objectives, groundwater modeling, and BRA are summarized and cumulative risk assessed. The waste area group (WAG) -wide ecological risk assessment (ERA), which was prepared under the Comprehensive RI/FS for INTEC (DOE-ID 1997), and the updating and reassessment of the data to be consistent with the OU 3-14 human health risk assessment (HHRA) are summarized. Preliminary lists of chemical- and location-specific applicable and/or relevant and appropriate requirements (ARARs) and remedial action objectives (RAOs) are presented. The information presented in this report forms the basis for the OU 3-14 Tank Farm Soil and Groundwater FS (DOE-ID 2006), which is a companion document to this RI/BRA.

9.1 RI/BRA Objectives Accomplished

The primary tasks of the OU 3-14 RI/BRA, as outlined in the RI/FS Work Plan (DOE-ID 2004), have been accomplished and include the following:

- Nature and extent of contamination. Determine the nature and extent of contamination for the OU 3-14 sites. Information from past tank farm excavations has been evaluated to determine the extent of contaminated backfill.

- Baseline risk assessment. Evaluate risks to human health from exposure to radioactively contaminated soil. A focused BRA was completed that reevaluated risks for external exposure and used information from the OU 3-13 BRA for pathways that do not cause unacceptable risk.

- Fate and transport modeling. Update the INTEC fate and transport model to predict if maximum contaminant levels (MCLs) will be met in the Snake River Plain Aquifer (SRPA). The OU 3-14 source term estimates were improved based on process knowledge and site characterization. The model used new data from perched water and groundwater investigations, a geostatistical representation of the stratigraphy, both OU 3-13 and 3-14 source terms, and updated K_ds based on an extensive literature search.

- Remedy selection basis. Provide a basis for selecting a final remedy for tank farm alluvium and the SRPA. This RI/BRA presents the information necessary to prepare an FS and select a final remedy for tank farm alluvium and the SRPA. The RI/BRA information will be used to evaluate final remedy alternatives for both the SRPA and tank farm alluvium in the FS. Soil has been archived for use in future treatability studies, if necessary.

9.2 Human Health Risk Assessment Summary

The OU 3-14 BRA for human health relied in part on the BRA that had been previously prepared for the tank farm soil under OU 3-13. The OU 3-13 BRA concluded that the only surface exposure route that presented an excess cancer risk greater than one in a million was from external radiation from soil contaminated with Cs-137. Therefore, the OU 3-14 BRA recalculated the risks from direct exposure to surface soil for OU 3-14 sites based on data obtained during the OU 3-14 RI. These data included both historical information on reuse of contaminated backfill in the tank farm and new analytical data collected in 2004. Due to information obtained that indicated contaminated soil from the individual tank farm

release sites had been reused as backfill outside the boundaries of the release sites, the tank farm soil inside the tank farm boundary was grouped as one site. This also reflects the unlikelihood that a worker would spend an entire 25 years working only at one small tank farm site, the largest of which is about 150 ft long and 50 ft wide.

The risk of developing excess cancer to unprotected current and future occupational workers from direct exposure over 25 years to soil contaminated with Cs-137 in the top 4 ft inside the tank farm boundary was determined to exceed 1 in 10,000. The risk to current workers from direct exposure over 25 years to soil in the top 4 ft at Site CPP-15 and CPP-58 was determined to exceed 1 in 10,000. However, this assumes that no institutional controls, such as current administrative controls, are in place to protect the workers. No credit was taken for the electrical duct banks and transformers that cover Site CPP-15. The risk to a future worker from Sites CPP-15 and CPP-58 is less than 1 in 10,000 due to radioactive decay.

The SRPA currently exceeds MCLs for Sr-90 and I-129 from the former injection well and Tc-99 and nitrate as nitrogen from the tank farm releases, primarily Site CPP-31. The groundwater model predicts that Sr-90 will exceed MCLs beyond the year 2095 and the other contaminants of concern (COCs) will not. Sr-90 was identified as the only contaminant from the OU 3-14 tank farm releases that could adversely impact groundwater quality beyond the year 2095.

9.3 Cumulative Risk Assessment

The baseline risk results have been presented separately for the soil and groundwater pathways. The risk results for soil are summed across all COCs for the direct radiation pathway and also for the other surface pathways that were evaluated in the OU 3-13 RI/BRA. The risk contribution from the "other surface pathways" is always a few orders of magnitude lower than risk through the direct radiation surface pathway. Therefore, cumulative risk for the surface pathways, across all COCs, is not greater than the risk through the direct radiation pathway.

All OU 3-14 soil sites are located within the industrial use area and the future land use scenario is occupational use only. Current exposures are only through surface pathways. There is no groundwater pathway associated with current occupational exposures because the water supply wells currently in use at INTEC are located upgradient of the facility. Therefore, there is no possibility that a current worker would be exposed through both the surface and groundwater pathways. The cumulative risk calculated for the surface pathways is the cumulative risk for all pathways for the current occupational exposures and exceeds the 1E-04 risk-based level.

A future resident could hypothetically reside outside the industrial use area and would not be exposed to contaminated soil in the industrial use area. They could drill a well into portions of the SRPA well contaminated by INTEC releases. The residential land use scenario assumes that the resident may consume and otherwise use water from a groundwater well. The cumulative risk for a future resident is the total risk from the groundwater pathway.

The groundwater pathway modeling results are presented in terms of calculated peak concentrations of COCs in groundwater, the maximum concentration in 2095 and beyond, and also in terms of carcinogenic risk levels and noncarcinogenic hazard quotients for a future resident. The future resident consumes more water than a future worker so the risk numbers and hazard quotients presented are the higher of the two exposure scenarios and the more conservative. The maximum concentrations in 2095 are compared with the Idaho Ground Water Quality Standards, which are equivalent to the federal drinking water standards (MCLs). Because COCs move through the vadose zone toward the SRPA at different rates, the future time at which each COC reaches its peak concentration varies by COC. In

addition, the location at which one COC reaches its peak concentration in the aquifer is typically different from another COC. Although it is not appropriate to sum the peak risks for the groundwater COCs across both different times and different locations, the sum is presented in Table 8-7 as well as the hazard index (HI) for all noncarcinogens. The cumulative risk for groundwater is 3E-05 and the HI is 0.05. The actual risk and HI would be less because the maximum groundwater concentrations for each COC do not overlap in space and time. Although the risk from ingesting contaminated groundwater in 2095 and beyond is below the 1E-04 risk-based level, the exposure would be unacceptable because the groundwater is predicted to exceed drinking water standards for Sr-90. The predicted peak concentration at the end of the period of active institutional controls in 2095 is 18.6 pCi/L for Sr-90 and the MCL is 8 pCi/L.

A future worker inside the industrial use area could be exposed to both contaminated soil and contaminated groundwater. The risk to a future worker inside the tank farm boundary from external exposure to Cs-137 contaminated surface soil would exceed the 1E-04 risk-based level; and, therefore, the cumulative risk will also exceed the risk-based level. Because the risk to a future worker from ingestion of groundwater is several orders of magnitude less than the risk from direct exposure to soil inside the tank farm boundary, the cumulative risk for all pathways is not greater than the risk through the direct radiation pathway.

For a future worker in the year 2095 and beyond at Sites CPP-15 or CPP-58, which are located outside the tank farm boundary, the Cs-137 concentrations in the soil will have decayed to acceptable levels. However, ingestion of water that exceeds MCLs is unacceptable.

As discussed in the OU 3-14 RI/FS Work Plan (DOE-ID 2004), the residual risks from non-CERCLA sources at INTEC that are being closed under other programs (e.g., Waste Calcining Facility [WCF] and tank farm tanks, piping, and sand pads closures) need to be considered in the design of remedial alternatives for the tank farm soil and groundwater. This will ensure that the remedies for tank farm soil and groundwater will be protective when the cumulative effect of residual risks from both CERCLA and non-CERCLA sources at INTEC are considered. This is discussed in Section 1.3.12 of the OU 3-14 Feasibility Study (DOE-ID 2006).

9.4 Ecological Risk Assessment Summary

The ERA performed in the OU 3-13 RI/FS is presented in Section 28 of DOE-ID (1997). The OU 3-13 ERA follows the approach presented in the *Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL* (VanHorn, Hampton, and Morris 1995) and uses the 0 to 10-ft depth for evaluation, which is similar to the HHRA for residential intrusional scenario. The ERA for the Tank Farm Group and the Tank Farm South Group of sites used the values provided by the HHRA for evaluation. The results of this assessment found that several metals and radionuclides are potentially at levels of concern. Due to the availability of new sampling data, updated input parameters, and toxicity data as documented in the OU 10-04 Comprehensive RI/FS (DOE-ID 2001) for ecological receptors, these data were reassessed to ensure that the conclusions made in the OU 3-13 RI/FS are still valid.

For consistency with the HHRA, calculations were made separately for Sites CPP-15, CPP-58, and Soil inside the Tank Farm Boundary. Maximum concentrations of nonradionuclides do not pose unacceptable risk to ecological receptors at these sites. Maximum concentrations of radionuclides do not pose unacceptable risk to ecological receptors at CPP-15 and CPP-58. For Soil inside the Tank Farm Boundary, external exposure of ecological receptors to radionuclides is not a concern, but internal exposure to radionuclides could possibly impact ecological receptors (HIs over 400). Therefore, care should be taken to ensure that RAOs inside the tank farm boundary also include consideration of ecological receptors. However, this site was assessed as if it had freely available habitat for ecological

receptors and this is not the case. A more detailed assessment that takes these facts into account may result in a reduced calculated risk.

9.5 Identification of Preliminary Applicable or Relevant and Appropriate Requirements

This section identifies the preliminary chemical- and location-specific ARARs for OU 3-14 based on site characteristics and knowledge of COCs (Table 9-1). Further identification and definition of ARARs, including the action-specific ARARs, will be conducted through a phased process as remedial action alternatives appropriate for the site are identified and presented in the OU 3-14 RI/FS, Proposed Plan, and Record of Decision (ROD).

CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (42 USC § 9601, Public Law 99-499), requires the selection of remedial actions that satisfy two threshold criteria: (a) overall protection of human health and the environment and (b) compliance with ARARs. Remedies must address substantive standards, requirements, criteria, or limitations under federal environmental laws and any promulgated state environmental requirements, standards, criteria, or limitations that are more stringent than corresponding federal standards. In addition, the importance of nonpromulgated criteria or other advisory information, called "to be considered" (TBC) criteria, is

Table 9-1. Preliminary list of ARARs for tank farm soil and groundwater.

Statute or Requirement	Citation	Applicable (A), or Relevant and Appropriate (R&A)	Comments
Chemical-specific			
Hazardous Waste Determination	IDAPA 58.01.05.006 (40 CFR 262.11)	A	Applies to waste generated during remediation activities.
Hazardous Waste Characteristics Identification	IDAPA 58.01.05.005 (40 CFR 261.20 through .24)	A	Applies if soil is excavated and consolidated to facilitate its management or treated or placed in long-term storage awaiting disposal.
Idaho Fugitive Dust Emissions	IDAPA 58.01.01.650 et seq.	A	Applies to control of dust during site disturbance and well drilling activities.
Rules for the Control of Air Pollution in Idaho (Air Toxics Rules)	IDAPA 58.01.01.585 and 58.01.01.586	A	Applies to control of emissions during site disturbance and well drilling activities.
Idaho Ground Water Quality Standards	IDAPA 58.01.11.200	A	Applies to groundwater standards.
National Emission Standards for Hazardous Air Pollutants (NESHAP)	40 CFR 61.92 40 CFR 61.93 40 CFR 61.94(a)	A	Applies to radionuclide air emissions generated from the CERCLA activities.

formally recognized in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) in the development of remediation goals or cleanup levels. The ARAR identification process for the OU 3-14 comprehensive investigation consists of evaluating sites against the *CERCLA Compliance with Other Laws Manual* (EPA 1988) to identify preliminary chemical- and location-specific ARARs as identified in the following sections.

9.5.1 Chemical-Specific ARARs

Chemical-specific ARARs are usually health- or risk-based values that establish the acceptable amounts or concentrations of a chemical that may be found in or discharged to the ambient environment. Within the context of the effectiveness evaluation, chemical-specific ARARs assume significance as each alternative is evaluated for its effectiveness in protecting human health and the environment.

The ability to protect human health and the environment is a threshold criterion that CERCLA remedial actions must meet to be considered a preferred remedy. A remedy would be considered protective if it adequately eliminates, reduces, or controls all current and potential risks posed through exposure pathways at the site. In accomplishing protectiveness, a remediation alternative must meet or exceed ARARs or other risk-based levels established when ARARs do not exist or are waived.

In both the NCP and the *CERCLA Compliance with Other Laws Manual* (EPA 1988), the EPA specifies that when ARARs are not available for a given chemical or when such chemical-specific ARARs are not sufficient to be protective, risk-based levels should be identified or developed to ensure that a remedy is protective. Both carcinogenic and noncarcinogenic effects are considered in determining risk-based levels and evaluating protectiveness. For carcinogenic effects, the health advisory or risk-based levels are selected so that the total lifetime risk to the exposed population of all contaminants falls within the acceptable range of 10^{-4} to 10^{-6}. The 10^{-6} risk level is specified by EPA as a point of departure for levels of exposure, as determined by EPA reference doses (RfDs), taking into account the effects of other contaminants at the site. An example of departure from the 10^{-6} risk level, when taking into account the effects of other contaminants, is the risk goals identified in the OU 3-13 ROD (DOE-ID 1999). This document identified remediation goals based on a 1×10^{-4} cumulative carcinogenic risk or a noncarcinogenic HI of 1 for contaminants, whichever is more restrictive for a given contaminant.

Therefore, chemical-specific ARARs serve two primary purposes:

- To identify chemical-specific requirements that must be met, as a minimum, by a selected remedial action alternative (unless a waiver is obtained)
- To provide a basis for establishing appropriate chemical-specific cleanup levels.

The potential chemical-specific ARARs pertinent to the OU 3-14 sites include the “Idaho Ground Water Quality Standards” (IDAPA 58.01.11.200); the National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 61.92); and the State of Idaho’s rule governing new sources of toxic air pollutants (IDAPA 58.01.01.585 and 58.01.01.586). The Idaho Ground Water Quality Standards establish the standards for groundwater quality and are used to assess the protectiveness of alternatives. National Emission Standards for Hazardous Air Pollutants establishes the emission limits for radionuclides from an entire facility to an amount that would not cause a member of the public to receive an effective dose equivalent of 10 mrem per year. These requirements are considered potentially applicable to possible remedial actions that may be undertaken at OU 3-14. Remedial options would be assessed against the State of Idaho’s rule on new sources of toxic air pollutants. If toxic air pollutant emissions exceed relevant screening levels, appropriate air modeling would determine ambient air concentration. Reasonable available control technologies would be employed to control emissions if acceptable ambient air concentrations were exceeded. If remedial action is necessary, air-screening analysis would

determine the levels of emissions likely to be associated with the options being proposed. The INL Site is categorized as an attainment or unclassified area for ambient air quality (42 USC 7401 et seq.) and, therefore, is subject to IDAPA 58.01.01.575-77 and 40 CFR 50.

9.5.2 Location-Specific ARARs

Location-specific ARARs are regulatory requirements or restrictions on activities in specific locations that a given remedial action must meet. There are no general location-specific regulatory requirements for OU 3-14.

9.5.3 To-Be-Considered Guidance

TBC criteria are advisories, guidelines, or policies that do not meet the definition of ARARs. These criteria may assist in determining protective criteria in the absence of specific ARARs. Preliminary TBC criteria for the OU 3-14 site include the following:

- DOE orders and manuals
- Executive orders
- Federal and state rules pertaining to relevant subjects that are not promulgated criteria, limits, or standards by definition of Section 121[d] of CERCLA (42 USC 9601)
- EPA guidance documents
- Remedial action decisions at similar Superfund sites.

Table 9-2 lists potential TBC criteria for OU 3-14.

Table 9-2. Preliminary list of TBCs.

Statute or Requirement	Citation	Applicable (A), or Relevant and Appropriate (R&A)	Comments
To Be Considered (TBC)			
Radiation Protection of the Public and Environment	DOE Order 5400.5	TBC	Exposures to the public will be kept as low as reasonably achievable (ALARA) using administrative and engineering controls before, during, and after remediation activities.
Radioactive Waste Management (RWMC)	DOE Order 435.1	TBC	Substantive requirements will be met for management of radiologically contaminated CERCLA wastes.
Region 10 Final Policy on Institutional Controls at Federal Facilities	Institutional controls	TBC	Applies to controls for contamination left in place.

9.6 Recommended Remedial Action Objectives

RAOs that affect the SRPA are defined as follows:

I. Prior to 2095, prevent current workers and the general public from ingesting SRPA groundwater contaminated by INTEC releases that exceeds applicable State of Idaho groundwater quality standards (currently identified as 8 pCi/L for Sr-90, 900 pCi/L for Tc-99, 1 pCi/L for I-129, and 10 mg/L for nitrate measured as nitrogen); a cumulative excess cancer risk from all carcinogens of 1 in 10,000; or an HI of 1.

II. In 2095 and beyond, ensure that concentrations of all contaminants in SRPA groundwater contaminated by INTEC releases do not exceed State of Idaho groundwater quality standards, a cumulative excess cancer risk from all carcinogens of 1 in 10,000, or an HI of 1.

Total excess cancer risk and HI will be determined by summing contaminants that are predicted to be in the SRPA at the same place and time. The results of the BRA model predicted that Sr-90 would exceed the MCL of 8 pCi/L in 2095 and beyond. No noncarcinogens have been identified that would exceed an MCL, and the total HI is currently below 1 and predicted to remain below 1.

RAO II can potentially be met through combinations of actions (a) on the alluvium and/or the SRPA under OU 3-14 and (b) on the vadose zone below the alluvium (perched water, interbeds, and/or basalt) and/or recharge (controls on infiltration and anthropogenic water) under OU 3-13 Group 4.

RAOs for the OU 3-14 soils are defined as follows:

III. Prevent external exposure to current and future workers inside the tank farm boundary to Cs-137 contaminated alluvium in the top 4 ft of soil, including biotic transport, that would exceed an excess cancer risk of 1 in 10,000.

IV. Prevent external exposure to current workers at Sites CPP-15 and CPP-58 to Cs-137 contaminated alluvium in the top 4 ft of soil that would exceed an excess cancer risk of 1 in 10,000.

V. Prevent internal exposure to Cs-137 and Sr-90 inside the tank farm boundary that would exceed an ecological hazard quotient of 10 for an individual contaminant and a total HI of 10.

The RAOs for soil are focused on external exposure because exposure from gamma-emitting radionuclides represents the predominant risk. The risk and hazard quotient for other exposure routes, such as soil ingestion, are well below the risk threshold of 1×10^{-4} or the hazard quotient of 1 and are extremely small (0.0002% or less of the total) relative to impacts from external exposure. RAO III also addresses the potential for biotic transport of contamination as a possible pathway. To ensure the protection of workers, it is necessary to inhibit transport of COCs to the surface by plants and animals. Intrusion by deep-rooted plants and burrowing mammals and insects (ants) into contaminated soil can create a pathway for movement of contamination to the surface.

9.7 Conclusions and Feasibility Study

All OU 3-14 sites pose an unacceptable risk. The risk from external exposure to Cs-137 contaminated alluvium over the entire surface of the tank farm (top 4 ft), including material that was used as backfill during construction and maintenance activities, is greater than 1 in 10,000 for current and

future workers. The two sites that are outside the tank farm, CPP-15 and CPP-58, exceed the 1-in-10,000 risk-based level from external exposure to Cs-137 contaminated alluvium in the top 4 ft for current workers. Hypothetical future residents living outside the industrial use area in the year 2095 and beyond could drill a well into portions of the SRPA that are contaminated at levels above the MCLs from INTEC CERCLA sources for Sr-90. The other contaminants in the SRPA that are currently at or above the MCLs (Tc-99, I-129, and nitrate measured as nitrogen) are predicted by modeling to meet drinking water standards before the year 2095.

The Feasibility Study (FS) (DOE-ID 2006) is a companion document to this RI/BRA and evaluates remedies for the OU 3-14 soil sites and groundwater contaminated by INTEC CERCLA releases. Although the release at Site CPP-31 contributed greater than 87% of the Sr-90 source term, the risk to groundwater from residual Sr-90 remaining in the alluvium is negligible. However, alternatives to remediate the soil at this site will be evaluated in the FS to address uncertainty in the model and to provide the risk managers with options. Therefore, remedies for the alluvium to protect groundwater as well as remedies for the groundwater will be evaluated in the FS. No additional remedial actions beyond the remedy to protect workers from external radiation will be considered in the FS for the other OU 3-14 sites because these other sites are even less significant contributors to groundwater risk.

The FS will integrate tank farm remedies for the contaminated alluvium with other programs that operate within the tank farm to ensure that the remedies are compatible. The FS will also identify remedies that include actions to reduce perched water in combination with actions on the OU 3-14 alluvium and groundwater. The FS will include assumptions about groundwater source terms that may be left behind from tank closure activities, such as waste residuals in the tanks, piping, and sand pads. It will also integrate CERCLA remedies with the timing of planned activities within the tank farm associated with tank closures, sodium-bearing waste (SBW), and use of underground lines that run through the tank farm, such as process equipment waste (PEW) lines.

9.8 References

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Appendix A

Groundwater Risk Pathway Model Development, Calibration and Predictive Results

Peter Martian
Chinnathambi Esakkiperumal
Annette L. Schafer

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ACRONYMS

bgs	below ground surface
BRA	baseline risk assessment
BM	below massive (basalt flow)
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFA	Central Facilities Area
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	Chemical Processing Plant
DEQ	Department of Environmental Quality (Idaho)
DOE	Department of Energy
EDW	Environmental Data Warehouse
EPA	U.S. Environmental Protection Agency
ESRP	Eastern Snake River Plain
FS	feasibility study
ICDF	INEEL CERCLA Disposal Facility
ICP	Idaho Cleanup Project
ICPP	Idaho Chemical Processing Plant
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
Kd	soil/water partition coefficient
LET&D	Liquid Effluent Treatment and Disposal (facility)
MCL	maximum contaminant level
MRDS	monitoring report/decision summary
MWTS	monitoring well and tracer study
NPL	National Priorities List

OU	operable unit
PA	performance assessment
PEW	process equipment waste
RI	remedial investigation
RI/BRA	remedial investigation/baseline risk assessment
RI/FS	remedial investigation/feasibility study
RMS	root mean square
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area (at RWMC)
SRPA	Snake River Plain Aquifer
SVOC	semivolatile organic compound
TAN	Test Area North
USGS	United States Geological Survey
VOC	volatile organic compound
WAG	waste area group
WCF	Waste Calcining Facility

Groundwater Risk Pathway Model Development, Calibration and Predictive Results

A-1 INTRODUCTION

Idaho Nuclear Technology and Engineering Center (INTEC) is a large industrial complex located in the south-central portion of the Idaho National Laboratory (INL) Site. The historical mission of INTEC, formerly known as the Chemical Processing Plant [CPP]) was to recover fissile uranium by reprocessing spent nuclear fuel. The resulting liquid waste generated from this process was acidic and radioactive. The liquid contained fission products, activation products, transuranic radionuclides, and various metals. The liquid waste was temporarily stored in an underground tank farm facility located at INTEC until the liquid radioactive waste was converted to a solid granular form. Leaks and spills from piping and valves have occurred during waste transfer activities, thereby releasing contaminants to the surrounding soil. Figure A-1-1 illustrates the location of the INL Site, INTEC, and tank farm.

The INL Site is on the National Priority List (NPL) and is subject to the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The tank farm contaminated soils and groundwater are undergoing a Remedial Investigation and Feasibility Study (RI/FS) and has been designated Waste Area Group 3 (WAG 3), Operable Unit (OU) 3-14. Infiltrating water, resulting from natural and anthropogenic sources, moves down through the contaminated soil, mobilizes contaminants, and may eventually transport them to the aquifer. It is necessary to predict the future impact of the contaminated soil on the Snake River Plain Aquifer to support the RI/FS. This report documents the INTEC conceptual and numerical model, which will be used as the basis for predicting future groundwater contaminant concentrations resulting from the INTEC CERCLA releases. The groundwater concentrations are used in exposure calculations to assess risk from the groundwater ingestion pathway and to compare to regulatory groundwater concentration limits.

A-1.1 Report Organization

Simulation of flow and contaminant transport from the INTEC ground surface to the aquifer requires an understanding of the movement of water and of the chemical behavior of solutes in the subsurface. In general, the modeling process includes the following tasks: (1) definition of the modeling purpose and goals, (2) field data collection and review, (3) conceptual model development, (4) code selection, (5) conceptual model parameterization, (6) parameter adjustment to calibrate the model, (7) model sensitivity analysis, (8) prediction of aquifer concentrations, and (9) assessment of model prediction uncertainty. These tasks are presented below:

- Definition of Modeling Purpose and Goals - This task guides the entire model development because the end use of the model defines the complexity needed in the conceptual model, and the data needed to parameterize and calibrate the model. This task is presented in Section 2 along with the motivation for updating the INTEC conceptual and numerical models.

- Field Data Collection and Review - This task provides data needed for model development and identifies potential data gaps. The data available for developing the OU 3-14 groundwater models is presented for the vadose zone and aquifer in Sections 3 and 4, respectively.

- Conceptual Model Development - This task is an interpretation of collected data to understand how water and contaminants move in the subsurface. The INTEC conceptual model development has already been performed and is not presented in this Appendix, but can be found in the *Phase 1 Monitoring Well and Tracer Study Report for Operable Unit 3-13, Group 4, Perched Water* (DOE-ID 2003a).

- Code Selection - The purpose of this task is to select a software package that best answers the contaminant fate and transport simulation needs. An informal code selection task was performed and the TETRAD simulator (Vinsome and Shook 1993) was found to be the best software for simulating the unsaturated and saturated zone below INTEC. The simulation code is presented in Section 6.

- Conceptual model Parameterization - This task is performed by quantifying the conceptual model into a numerical model. The quantification requires assigning physical locations to important structures (i.e., interbeds and basalt flows) and assigning hydrologic and transport properties to these structures. The vadose zone and aquifer conceptual models and simulation methodology are presented in Section 5.

- Parameter Adjustment to Calibrate the Model - This task is performed by adjusting model hydrologic and transport parameters until simulated conditions agree with observations. It is not feasible for a numerical model, based on averaged hydrologic and transport properties, to exactly represent each field observation of vadose zone water content, perched water level, or solute concentrations. Instead the goal is to obtain the best overall match in water and solute movement. The vadose zone and aquifer model calibration were two very distinct tasks and they are presented in two sections. Section 7 presents the vadose zone model calibration process, and Section 8 presents the aquifer calibration process.

- Prediction of Aquifer Concentrations - This task uses the calibrated model to predict the future state of the system. The final model groundwater risk predictions are the basis for choosing tank farm remedial actions. The predictive results are presented in Section 9 along with identification of contaminants predicted to threaten the aquifer.

- Model Sensitivity Analysis - This task is performed to determine model sensitivity to input data. The data that results in the greatest model sensitivity can then be used to guide field data collection activities, which are the most valuable to reduce model prediction uncertainty. The results of the sensitivity analysis can also be used to guide the assessment of final prediction uncertainty. Model parameters that produce insensitive model results do not need to be included in the uncertainty analysis. The model sensitivity is presented in Section 10.

- Assessment of Model Prediction Uncertainty - Model prediction uncertainty is assessed to quantify the uncertainty in predicted future state given the uncertainty in model input data. The model uncertainty can be used to increase confidence in remedial decisions or guide further data collection activities. The assessment of model limitations (uncertainty) due to parameter sensitivity is presented in Section 10 along with the sensitivity analysis.

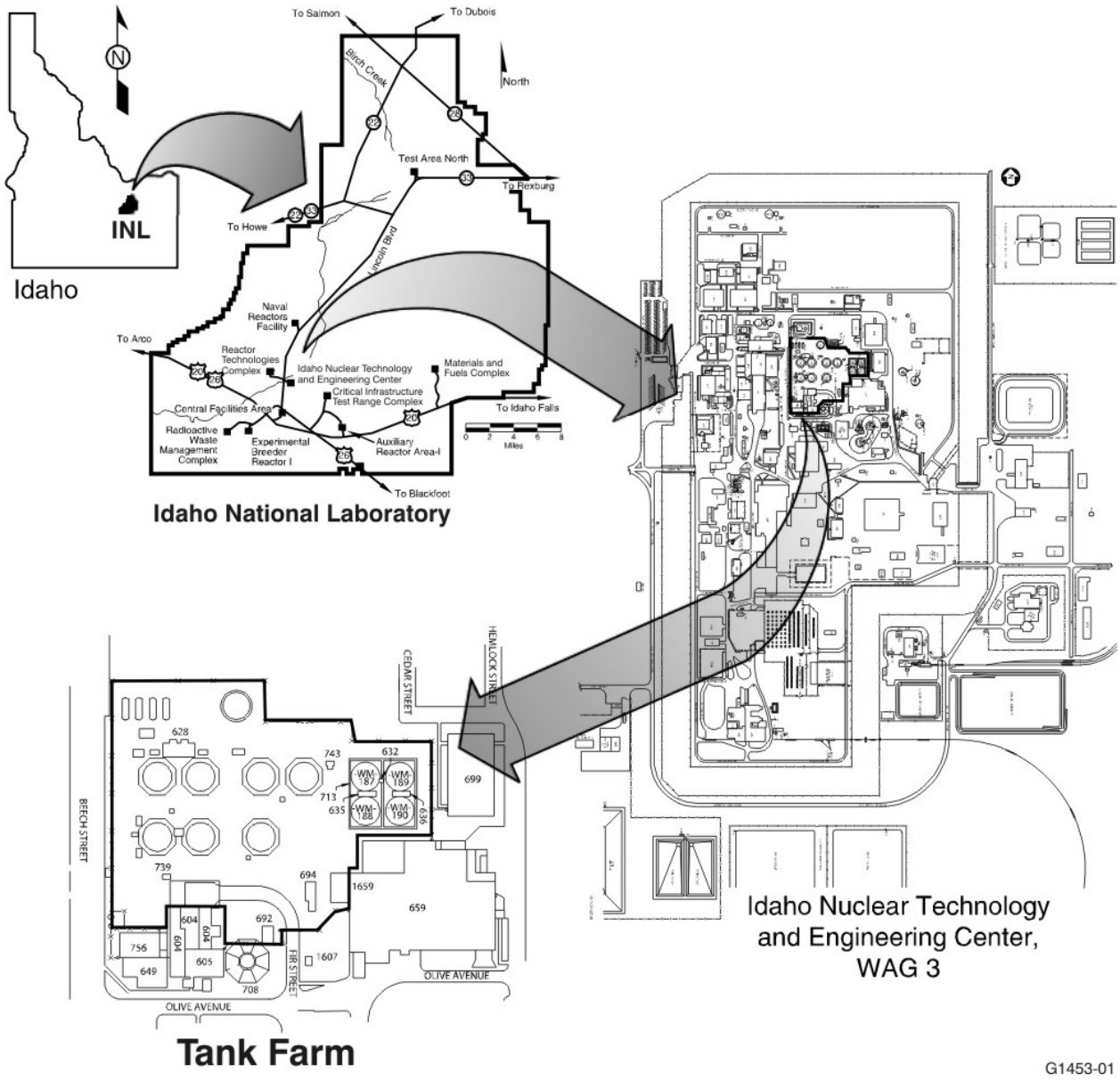

Figure A-1-1. Map showing the location of the INL Site, INTEC, and the tank farm (from Figure 1-1 of